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## ANORTHITE FROM CALIFORNIA

FRANKLIN S. MILLER, *Harvard University.*

In the course of a petrologic study of the San Marcos gabbro,<sup>1</sup> in the San Luis Rey quadrangle, California, it was found that the olivine-bearing phases of the rock are composed predominantly of a plagioclase feldspar which falls well within the composition range of anorthite (94% An). Since a number of composition determinations by means of index liquids showed the calcic plagioclase to be remarkably uniform in its optical properties and since much of it is altogether free from zoning, this anorthite seemed to afford a favorable opportunity for obtaining accurate data to check the existing feldspar curves. The results of a study of the optical properties of this anorthite, together with chemical analyses of both the mineral and the rock in which it occurs, are given below.

The anorthite- and olivine-bearing gabbroid rocks are ordinary plutonic types belonging to the complex Peninsular Range batholith of southern California. They are associated in the San Marcos formation with other gabbroid rocks containing normal labradorite feldspar. The gabbroid rocks appear as a number of small irregular masses among the more prominent quartz diorites and granodiorites of the batholith. The olivine- and anorthite-bearing rocks are estimated to outcrop over an aggregate area of eight square miles within the San Luis Rey quadrangle. This quadrangle makes up the northwestern part of San Diego County. Similar anorthite-bearing rocks have been reported from adjoining portions of the batholith in San Diego County by Lawson,<sup>2</sup> Kessler and Hamilton,<sup>3</sup> and Hudson.<sup>4</sup>

<sup>1</sup> Miller, Franklin S., *Petrology of the San Marcos Gabbro, San Luis Rey quadrangle, California*, unpublished doctorate thesis, Harvard University, May 1934.

<sup>2</sup> Lawson, A. C., *The Orbicular Gabbro at Dehesa, San Diego County, California: Bull. Univ. Calif. Publ., Dept. Geol.*, vol. 3, pp. 383-396, 1904.

<sup>3</sup> Kessler, H. H., and Hamilton, W. R., *The Orbicular Gabbro of Dehesa, California: Am. Geol.*, vol. 34, pp. 133-140, 1904.

<sup>4</sup> Hudson, F. S., *Geology of the Cuyamaca Region of California: Bull. Univ. Calif. Publ., Dept. Geol.*, vol. 13, pp. 175-252, esp. pp. 193-207, 1922.

The principal mineral constituents of the rocks are anorthite, olivine, hypersthene, augite, and hornblende. Through marked local variations in the proportions of these minerals the rocks range from olivine norite and olivine gabbro to troctolite and hornblende-olivine gabbro. There are also very small patches of anorthosite. All the rocks are dominantly feldspathic with anorthite amounting to more than 60 per cent by volume. The type which occurs most widely and which may be considered the average rock of the group is an olivine norite with notable hornblende, such as is represented by the analyzed specimen (354). Like the mineral composition, the grain size of the rocks shows striking variations over short distances from less than 0.5 mm. to more than 5.0 mm.; but the general texture and the composition of the plagioclase remain comparatively uniform.<sup>5</sup>

Analysis		Norm		Mode	
SiO <sub>2</sub>	42.86	Or	0.56	Plagioclase	67
TiO <sub>2</sub>	0.18	Ab	6.29	Hornblende	11
Al <sub>2</sub> O <sub>3</sub>	24.94	An	64.22	Hypersthene	2
Fe <sub>2</sub> O <sub>3</sub>	2.13	Di	0.68	Olivine	18
FeO	6.14	Hy	4.09	Iron Ore	0.2
MnO	0.06	Ol	20.09	Spinel	2
MgO	9.28	Mt	3.02	Iddingsite	0.2
CaO	13.08	Il	0.46		
Na <sub>2</sub> O	0.76				100.4
K <sub>2</sub> O	0.09		99.41		
H <sub>2</sub> O	0.78	Normative		Modal	
S	0.03	Plagioclase		Plagioclase	
		91% An		94% An	
	100.33				

The rock (354) of the above analysis, norm, and mode is a typical hornblende-bearing olivine norite from the northwest end of the summit ridge of Pala Mountain at 2050 feet elevation (San Luis Rey quadrangle, California, topographic sheet). It is interesting because of its low silica content for an ordinary feldspathic gabbroid rock. In this respect it corresponds to many ultra-mafic rocks. Yet it differs from the type allivalites and eucrites of Harker<sup>6</sup> in its lower content of mafic minerals and less marked ultramafic affinities. The analysis was made by F. A. Gonyer in

<sup>5</sup> The details of the occurrence and relationships of these calcic plagioclase rocks will be described in a later paper.

<sup>6</sup> Harker, A., The Geology of the Small Isles of Invernessshire: *Memoir Geol. Surv. Scot.*, 210 pp, 1908.



the laboratory of the Department of Mineralogy and Petrography at Harvard University. The mode is based on measurements with a modified Wentworth recording micrometer recalculated to weight percentages.

The anorthite occurs in nearly equant anhedral grains which show no crystal boundaries. The resulting allotriomorphic texture is designated "mosaic," employing that term in the same sense in



FIG. 1. Mosaic texture of the anorthite in an olivine-bearing phase (troctolite) of the San Marcos gabbro.

which it has been used by Graton and Murdoch<sup>7</sup> for the entirely similar textures of such minerals as pyrite in polished sections of the metallic ores. The mineral grains are bounded by straight or gently and regularly curving lines (as seen in thin section) which are independent of the crystal structure and which tend to give them polygonal shapes, such as might have been produced by the mutual interference of growing crystals (Figure 1). The boundaries

<sup>7</sup> Graton, L. C., and Murdoch, J., The Sulphide Ores of Copper. Some Results of Microscopic Study: *Trans. Amer. Inst. Min. Eng.*, vol. 45, pp. 26-93, p. 36, 1914.

of three contiguous grains often meet at a triple point; occasionally the boundaries of four grains meet at a quadruple point. The grains are all of the same order of size, so that the texture is equigranular. Olivine, augite, or hornblende at times enter into the mosaic along with the anorthite.

The term "mosaic" has sometimes been used as roughly synonymous with "granulitic" in the sense of the latter word advocated by the committee on British petrographic nomenclature.<sup>8</sup> It is so listed in the standard handbooks,<sup>9</sup> but without any citation of an original or specific definition. The term granulitic itself has been employed in two different senses, one, following the original definition by Judd in 1886, equivalent to the "intergranular" of Evans and the other, following Michel-Levy and the usage recommended by the British committee, for "rocks characterized by even-sized and closely-fitting grains." Even in the latter sense "granulitic" is not strictly synonymous with "mosaic" as here defined and appears to be more applicable to metamorphic than to igneous rocks. It is suggested that "granulitic" be restricted to textures of metamorphic rocks, whether of igneous or sedimentary origin, and that "mosaic" be used for the truly primary texture of igneous rocks which corresponds to that described by Graton and Murdoch in the metallic ores.

Such a mosaic texture of the anorthite plagioclase is characteristic of the olivine-bearing rocks and distinguishes them from the other gabbroid rocks of the San Marcos formation. It is best developed in the rocks with the least hornblende. When any large amount of hornblende is present, there is a tendency for the plagioclase to show moderate zoning, to have a slightly less calcic average composition, a bytownite-anorthite with 87-92 per cent An, and to form thick tablets (parallel to (010)) with more or less definite crystal boundaries.

The anorthite, then, occurs in nearly equant anhedral grains. The grains are remarkably fresh and clear and free both from alter-

<sup>8</sup> Watts, et al., Report of the Committee on British Petrographic Nomenclature, *Mineral. Mag.*, vol. 19, pp. 140-141, 1921

<sup>9</sup> Holmes, A., *The Nomenclature of Petrology*, 2nd Edition, London, Thomas Murby, 284 pp., p. 162, 1928.

Grout, F. F., *Petrography and Petrology*, New York, McGraw-Hill, 522 pp., p. 42, 1932.

Johannsen, A., *A Descriptive Petrography of the Igneous Rocks*, Chicago, Univ. of Chicago Press, vol. 1, 267 pp., p. 220, 1931.



ation products, such as kaolin and sericite, and from inclusions of any sort. Zoning is practically absent in the majority of the specimens. Several grams of the anorthite were separated from the powdered rock remaining from the chemical analysis (354) by the following process. The powder was ground to pass a 200-mesh screen. The fine dust which failed to settle in a beaker of water within about a minute was decanted off. As much of the mafic material as possible was removed by exposing the remaining powder to a strong electromagnet, and the powder was further purified by gravity separation with bromoform. All the other rock minerals were heavier than the anorthite and settled readily in a liquid with a specific gravity of 2.80. The separation was repeated several times, until a clean anorthite concentrate was secured, the gravity of the liquid being varied to remove mixed grains. Under the microscope less than 1 per cent of the grains showed any trace of attached extraneous material. The total amount of such material, chiefly hornblende, was only a few tenths of a per cent. The powder was analyzed by F. A. Gonyer.

Analysis		Molecular Numbers	Norm	
SiO <sub>2</sub>	43.77	.730	Or	0.56
Al <sub>2</sub> O <sub>3</sub>	36.11	.354	Ab	5.76
Fe <sub>2</sub> O <sub>3</sub>	0.09	.001	An	93.13
MgO	0.07	.002		
CaO	18.73	.335		99.45
Na <sub>2</sub> O	0.67	.011	Recalculated to 100% gives 93.6 or 94% An.	
K <sub>2</sub> O	0.11	.001		
H <sub>2</sub> O	0.40			
		99.95		

The computation shows the analysis to have a slight deficiency of silica and a slight excess of alumina as compared with lime and the alkalis. Calculation of the plagioclase composition on the basis of the ratio of Al<sub>2</sub>O<sub>3</sub> to SiO<sub>2</sub> alone gives 95 plus per cent An. The average of the two methods of calculation is nearer to 94 per cent An.

The principal physical and optical properties of the mineral, determined from the powder and the thin sections, may be summarized as follows:

Twinning according to the albite, pericline, and Carlsbad laws is prominent in many grains but is much less common than in most plagioclases. The twin lamellae of the polysynthetic types

are generally thicker and less numerous than in plagioclases of intermediate composition. In a number of thin sections less than half of the grains show any twinning, and this can be attributed only in small part to the orientation of twin planes parallel to the sections. The albite twinning is the most widespread type. The combination of albite and pericline twinning is very common. Carlsbad twins are rather rare. Other less common types of twin-

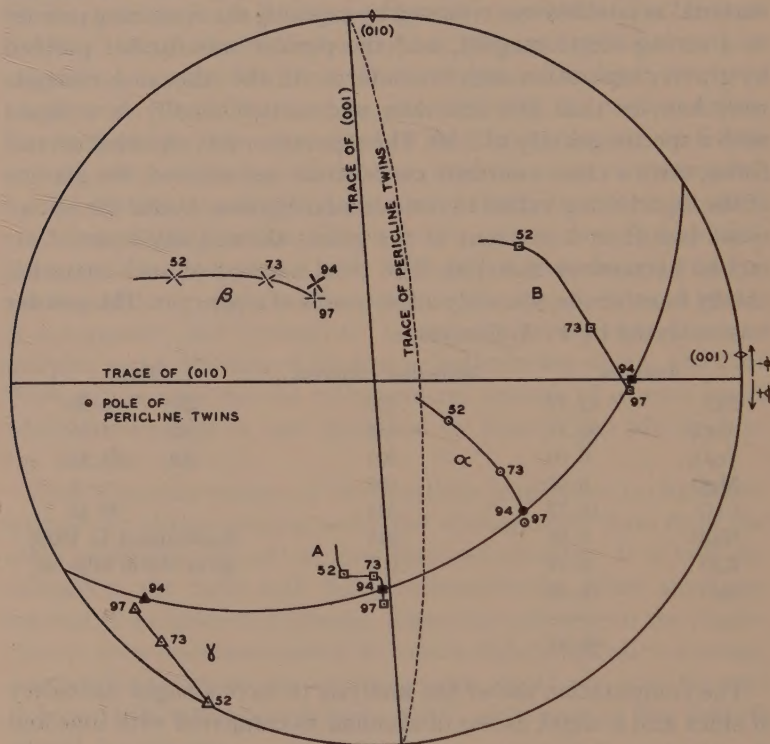


FIG. 2. Stereographic projection on the plane normal to the (001) and (010) cleavages. The ellipsoidal axes and the optic axes of the anorthite containing 94% An are plotted together with those of Duparc and Reinhard's calcic plagioclases.

ning may be present; but these can only be identified with the universal stage, and they did not appear in the dozen grains which were studied on the stage.

Both the (001) and (010) cleavages are well developed, but the (001) cleavage is the more perfect of the two. The cleavage angle is  $86^\circ$ . The specific gravity is 2.759.

## Optical Properties:

Refractive indices: $\alpha$	$= 1.574$
$\beta$	$= 1.582 -$
$\gamma$	$= 1.536 +$
Birefringence: $\gamma - \alpha$	$= 0.012 +$
Optical character	Negative
$2V$	$79^\circ$
Dispersion	$r < v$ (distinct)

The optical orientation is evident in figure 2, a stereographic projection after Duparc and Reinhard<sup>10</sup> on the plane normal to the (001) and (010) cleavages. The determined  $\phi$  and  $\rho$  values for the principal optical directions of the 94 per cent An plagioclase are listed below. The right-hand side of the trace of (010) is taken as the zero position for  $\phi$ ,  $+\phi$  being read  $180^\circ$  clockwise and  $-\phi$   $180^\circ$  counterclockwise. ( $\rho$  is measured outward from the center of the projection along the  $\phi$  direction.)

	$\phi$	$\rho$
$\alpha$	$+ 42$	57
$\beta$	$- 121$	34
$\gamma$	$+ 137$	82
Optic axis A	$+ 88$	60
Optic axis B	0	70
Pole of (010)	$+ 90$	90
Pole of (001)	$- 4$	90
Pole of pericline twins	$+ 176$	76

The principal extinction angles calculated from the stereographic projection by Fresnel's construction are:

On (001)	$\alpha' \wedge (010)$	$-35$
On (010)	$\alpha' \wedge (001)$	$-37$
$\perp$ (001) and (010)	$\alpha' \wedge (010)$	$+44$
" "	$\alpha' \wedge (001)$	$+42$
$\perp \alpha$	$\beta \wedge (010)$	$+35$
	$\beta \wedge (001)$	$-19$
$\perp \beta$	$\alpha \wedge (010)$	$-40$
	$\alpha \wedge (001)$	$+38$
$\perp \gamma$	$\alpha \wedge (010)$	$-50$
	$\alpha \wedge (001)$	$-65$

The maximum extinction angle in the zone normal to (010) was measured on the universal stage as  $53^\circ$ .

<sup>10</sup> Duparc, L. and Reinhard, M., La Détermination des Plagioclases dans les Coupes Minces: *Société de Physique et d'Histoire Naturelle de Genève*, vol. 40, pp. 1-149, 1924.



The refractive indices were first determined by the immersion method with liquids differing by 0.005. Then special liquids were made up to match each of the indices, and these liquids were checked with the Abbe refractometer. Sodium light was used throughout. The value for the optic angle represents the average of six measurements with the universal stage. The results varied from 78 to 81°, but three of the best measurements fell at 79° to the nearest degree. The optical orientation was also obtained by averaging several measurements on the universal stage. The results were found to differ systematically from the curves of Duparc and Reinhard in the directions indicated by the points plotted for 94 per cent An in Figure 2.

A number of other extinction angles were measured directly on the universal stage, in addition to the maximum extinction angle in the zone normal to (010), and in most cases these agreed with the calculated angles within a few degrees. However, it was not found practicable to measure directly all the angles listed above and difficulty was experienced in finding grains which were accurately enough oriented for satisfactory measurements, without a complete orientation of the grain on the universal stage. This is particularly true of the commonly used angle on a basal section measured to the (010) cleavage. The values of this extinction angle vary so rapidly with slight errors in orientation that it is of little use in determinative work.

The author wishes to express his thanks to Professor E. S. Larsen and to Harry Berman for their advice and criticism during the preparation of this paper.



## CELESTITE FROM CHITTENANGO FALLS, NEW YORK

NEWMAN W. THIBAUT, *Syracuse University.*

About three-quarters of a mile northwest of the village of Chittenango Falls, N. Y., a hitherto undescribed occurrence of celestite is to be found in an abandoned quarry bordering the State highway which follows Chittenango Creek.

The celestite, which is associated with a large amount of "dog-tooth" calcite, and smaller amounts of quartz and chalcedony, occurs as well-developed crystals lining very irregular geodic cavities, and as massive and fibrous veins which commonly connect the geodes. The cavities occur in several well-defined horizons near the base of the quarry face in a light gray dolomitic limestone which is probably the same formation that Hartnagel\* observed eight miles west at Stone Quarry falls, and which he has correlated with the Silurian Rondout waterlime of eastern New York.

The indices of refraction of several crystals were measured by the oil immersion method. In each case there was almost complete agreement of the measurements. The results obtained for sodium light are:

$$\alpha = 1.622, \quad \beta = 1.624, \quad \gamma = 1.632.$$

The probable limit of error is  $\pm .002$ . Since celestite cleaves perfectly parallel to the base,  $c(001)$ , and since the slow ray (Z) and the intermediate ray (Y) vibrate in the basal plane,  $\gamma$  and  $\beta$  were easily determined. The smallest  $n$  obtained on any fragment was taken as  $\alpha$ . This would occur on a fragment exhibiting cleavage parallel to  $b(010)$  which in celestite is distinct. For comparison the following published indices of refraction are given:

Dana: <sup>1</sup>	$\alpha = 1.622,$	$\beta = 1.624,$	$\gamma = 1.631.$
Winchell: <sup>2</sup>	$\alpha = 1.622,$	$\beta = 1.623,$	$\gamma = 1.631.$

The specific gravity was determined by the pycnometer method. About 25 small crystals were obtained from various widely scattered geodes. The average of three specific gravity determinations

\* Hartnagel, C. A., Preliminary Observations on the Cobleskill ("Coralline") Limestone of New York: *N. Y. State Mus. Bull.* 69, Report of the State Paleontologist for 1902, pp. 1160-1163, 1903.

<sup>1</sup> Dana, E. S., and Ford, W. E., *A Textbook of Mineralogy*, 4th Edition, p. 750. John Wiley and Sons, New York, 1932.

<sup>2</sup> Winchell, N. H., and A. N., *Elements of Optical Mineralogy*, vol. 2, p. 101. John Wiley and Sons, New York, 1927.

gave a value of 3.939. A determination made on five perfectly developed and exceptionally transparent crystals gave 3.968. In general the published values for the specific gravity of pure celestite range from 3.94 to 4.00.

A spectroscopic analysis of the Chittenango celestite, made by Professor David Trainer, Jr., of Colgate University, indicates no barium, and but little calcium isomorphously replacing the strontium.

#### CRYSTALLOGRAPHY

As is common with celestite, two types of crystals were observed, tabular parallel to the base,  $c(001)$ , and prismatic parallel to the crystallographic  $a$ -axis, the latter being so much more productive of forms that nearly all crystals measured were of this type. The crystals vary from the minutely prismatic types less than a millimeter in height and two millimeters long, to large, usually tabular, varieties some of which are as much as forty millimeters wide and ten millimeters thick. The average crystals, which are about six millimeters high and four to five millimeters wide, commonly exhibit rare forms.

As is indicated in Figures 1 and 2, the crystals are always attached roughly normal to the  $a$ -axis with the result that only one set of terminations about the brachy axis is developed.

About 75 crystals were examined under the high power of a binocular microscope. All the faces present on six of these were measured on the Goldschmidt two-circle reflecting goniometer, while only the rarer forms were measured on eight others.

The forms observed on the fourteen crystals are as follows:

$c(001)$ ;  $o(011)$ ;  $m(110)$ ;  $z(111)$ ;  $d(102)$ ;  $l(104)$ ;  
 $\Phi(106)$ ;  $\sigma(221)$ ;  $\gamma(122)$ ;  $g(103)$ ;  $b(010)$ ;  $v(324)$ ;  
 $\Delta_1(109)^*$ ;  $\Sigma(1.0.11)^*$ ;  $(3.0.29)?^*$ ;  $(3.0.31)?^*$

All the letters are those of Dana,<sup>3</sup> with the exception of  $\Phi$  which was first used by Buchrucker<sup>4</sup> but which does not appear in Dana's 6th Edition or any of its Appendices, and  $\Delta_1$  and  $\Sigma$  which are those of the author. The four forms designated by an asterisk (\*) are new for celestite, although  $(3.0.29)$  and  $(3.0.31)$  may be question-

<sup>3</sup> Dana, J. D., and E. S., *A System of Mineralogy*, 6th Edition, p. 905. John Wiley and Sons, New York, 1914.

<sup>4</sup> Buchrucker, *Die Mineralien der Erzlagerrstätten von Leogang in Salzburg: Zeit. f. Kryst.*, vol. 19, 1891.



able because of the quality of the signal and the complexity of the indices.

The combinations observed on the fourteen crystals are as follows:

TABLE 1.

1.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	<i>l</i> *	$\Phi$	.	.	.	.	$\Delta_1$	$\Sigma$	(3.0.29)?	(3.0.31)?
2.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	<i>l</i>	.	.	.	.	.	.	.	.	.
3.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	.	.	.	$\gamma$	.	.	.	.	.	.
4.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	<i>l</i>	$\Phi$	.	.	.	<i>b</i>	.	.	.	.
5.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	<i>l</i>	.	.	$\gamma$	.	.	.	.	.	.
6.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	.	.	.	$\sigma$	.	.	.	.	.	.
7.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	<i>l</i>	.	.	.	.	.	.	.	.	.
8.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	<i>l</i>	$\Phi$	.	.	.	.	.	.	.	.
9.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	.	.	.	$\sigma$	.	.	.	.	.	.
10.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	<i>l</i>	.	.	.	<i>g</i>	.	.	.	.	.
11.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	<i>l</i>	.	.	.	.	.	.	.	.	.
12.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	.	.	.	$\sigma$	.	.	.	.	.	.
13.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	<i>l</i>	.	.	.	.	.	.	.	.	.
14.	<i>c</i>	<i>o</i>	<i>m</i>	<i>z</i>	<i>d</i>	.	.	.	$\sigma$	.	.	<i>v</i>	.	.	.

\* Represented only by vicinal planes.

Figure 1 is a clinographic projection of the simplest crystal form (see Table 1) which, except for the relative sizes of the faces, is similar to one described by Gordon<sup>5</sup> from Franklin Furnace, N. J. Figure 2 shows a composite clinographic projection of all the forms observed except (3.0.29)? and (3.0.31)?

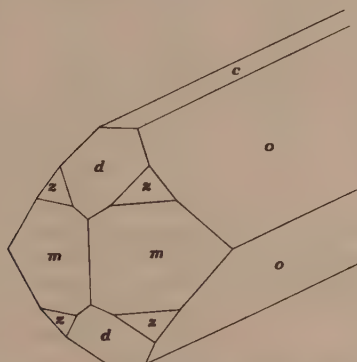


FIG. 1. Clinographic projection showing faces common to all crystals.

<sup>5</sup> Gordon, S. G., Crystallographic Notes on Glaucocroite, Willemite, Celestite, and Calcite from Franklin, N. J.: *Proc. Acad. Nat. Sci., Philadelphia*, vol. 74, pp. 105-112, 1923.

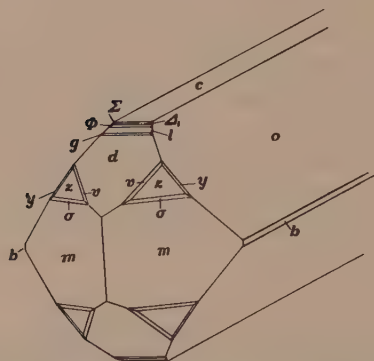


FIG. 2. Composite clinographic projection showing all faces observed except (3.0.29) and (3.0.31).

The measurements are given in Table 2.

The axial ratio calculated from the two largest forms capable of yielding results gives:

	average $\rho$	average $\phi$	$\rho_0$	$q_0$
<i>o</i>	$52^\circ 04\frac{1}{2}'$	$0^\circ 00'$	—	1.2834
<i>d</i>	$39^\circ 24'$	$89^\circ 55'$	1.6428	—
$a:b:c=0.7812:1:1.2834$				

TABLE 2  
AXIAL RATIO  $a:b:c=0.7811:1:1.2830$  (GOLDSCHMIDT<sup>6,7</sup>)

	Forms	Number of faces	Calculated angles		Measured angles	
			$\phi$	$\rho$	$\phi$	$\rho$
<i>o</i>	(011)	8	$0^\circ 00'$	$52^\circ 04'$	$0^\circ 00'$	$52^\circ 04\frac{1}{2}'$
<i>m</i>	(110)	12	$52^\circ 00'$	$90^\circ 00'$	$52^\circ 00'$	$90^\circ 02'$
<i>z</i>	(111)	12	$52^\circ 00'$	$64^\circ 22'$	$52^\circ 01'$	$64^\circ 27\frac{1}{2}'$
<i>d</i>	(102)	6	$90^\circ 00'$	$39^\circ 23'$	$89^\circ 55'$	$39^\circ 24'$
<i>l</i>	(104)	6	$90^\circ 00'$	$22^\circ 19'$	$89^\circ 56'$	$22^\circ 21\frac{1}{2}'$
$\Phi$	(106)	4	$90^\circ 00'$	$15^\circ 19'$	$89^\circ 55'$	$15^\circ 10'$
$\sigma$	(221)	4	$52^\circ 00'$	$76^\circ 30'$	$52^\circ 00'$	$76^\circ 37'$
<i>y</i>	(122)	3	$32^\circ 37'$	$56^\circ 43'$	$32^\circ 38'$	$56^\circ 49'$
<i>g</i>	(103)	2	$90^\circ 00'$	$28^\circ 42'$	$89^\circ 56'$	$28^\circ 49\frac{1}{2}'$
<i>b</i>	(010)	1	$0^\circ 00'$	$90^\circ 00'$	$0^\circ 03\frac{1}{2}'$	$90^\circ 01'$
<i>v</i>	(324)	1	$62^\circ 29'$	$54^\circ 15'$	$62^\circ 28'$	$54^\circ 24'$
$\Delta_1$	(109)	1	$90^\circ 00'$	$10^\circ 21'$	$89^\circ 59'$	$10^\circ 22\frac{1}{2}'$
$\Sigma$	(1.0.11)	1	$90^\circ 00'$	$8^\circ 30'$	$89^\circ 58'$	$8^\circ 26\frac{1}{2}'$
	(3.0.29)?	1	$90^\circ 00'$	$9^\circ 39'$	$89^\circ 58'$	$9^\circ 40\frac{1}{2}'$
	(3.0.31)?	1	$90^\circ 00'$	$9^\circ 02'$	$89^\circ 57'$	$9^\circ 00'$

<sup>6</sup> Goldschmidt, V., *Krystallographische Winkeltabellen*, p. 98. Julius Springes, Berlin, 1897.

<sup>7</sup> Goldschmidt, V., *Atlas der Krystallformen*, Text, Vol. 2, p. 163, Carl Winters Universitätsbuchhandlung, Heidelberg, 1913.



For comparison the following published ratios are given:

Goldschmidt:<sup>8,9</sup>

Goldschmidt and Gordon:<sup>10</sup>  $a:b:c=0.7811:1:1.2830$

Dana<sup>11</sup> following Auerbach:<sup>12</sup>  $a:b:c=0.77895:1:1.28005$

Rogers:<sup>13</sup>  $a:b:c=0.78058:1:1.28306$

The different forms may be characterized as follows:

$c(001)$ , which is always present, is almost always striated parallel to the  $b$ -axis of the crystal. The striae, which are to be found only on this form, usually consist of many distinct V-shaped grooves, of which that side nearest  $d(102)$  is very nearly perpendicular to  $c(001)$  while the other side is inclined from  $c$  less than eight degrees toward  $d$ . This inclination is by no means uniform among the various striae on the same crystal, with the result that upon rotation of the crystal from  $c$  toward  $d$ , a blur of images is usually to be noted.

$o(011)$  and  $m(110)$ , which are always present, are usually the largest and most perfect forms.

$z(111)$ , although always present except on a few large crystals, varies in size and shape according to the development of the larger adjacent forms.

$d(102)$  is also always present, but on five crystals vicinal faces are associated with it. The presence of similar vicinal planes has been observed by Hintze<sup>14</sup> on celestite from Lüneburg, Germany, and by Artini<sup>15</sup> on crystals from Romagna, Italy. The only vicinal planes on the Chittenango celestite are in each case situated between  $d$  and  $c$ , as was also observed by Artini on the Romagna crystals. The angle between  $d$  and the vicinal planes varies considerably with the individual crystals, but in no case does it exceed  $1^{\circ}15'$ . This variation is so great for the ten vicinal faces observed on the Chittenango celestite that a computation of indices would mean little. Although two vicinal planes,  $\rho=38^{\circ}55'$  and  $38^{\circ}53'$  agree well with Hintze's observation of  $38^{\circ}55'$  on crystals from Lüneburg, the agreement may be merely coincidence since the other eight faces diverge widely from any of his measurements. In several cases the vicinal planes are so arranged that very slight reëntrant angles are present, for, upon examining the faces in order from  $c$  to  $d$ , the observed angle does not constantly increase toward  $d$ . On badly weathered crystals face  $d$  curves slightly inward toward  $z$  and  $o$ , the axis of curvature being parallel to  $d$ , and also in the plane of the crystallographic  $a$ - and  $c$ -axes.

<sup>8</sup> Goldschmidt, V., *Winkeltabellen*, *ibid.*, p. 98.

<sup>9</sup> Goldschmidt, V., *Atlas der Krystallformen*, *ibid.*, p. 163.

<sup>10</sup> Calculated from the  $p_0$  and  $q_0$  values given in: Goldschmidt, V., and Gordon, S. G., *Crystallographic Tables for the Determination of Minerals: Acad. Nat. Sci., Philadelphia. Special Publication No. 2*, p. 32, 1928.

<sup>11</sup> Dana, J. D., and E. S., *ibid.*, p. 905.

<sup>12</sup> Auerbach, Bex and Herrengrund: *Ber. Ak. Wien.*, vol. 59, p. 549, 1869.

<sup>13</sup> Rogers, A. F., *Mineralogical Notes No. 3: Sch. Mines Quar.*, vol. 23, p. 134, 1902.

<sup>14</sup> Hintze, C., *Ueber Cölestin von Lüneburg und das Studium von Vicinalflächen: Zeit. f. Kryst.*, vol. 11, pp. 226-232, 1886.

<sup>15</sup> Artini, E., *Celestina di Romagna: Rend. Inst. Lomb. Sc.*, series 2, vol. 26, p. 325, 1893.

$l(104)$ , which is usually narrow, was in two cases replaced by vicinal planes, the angle in each case being:

Crystal 1.	22°08'	22°37'
Crystal 2.	22°08'	22°38' 23°06'

Although the agreement is striking, an attempt to calculate indices would result in very complex forms which would be highly uncertain.

$\Phi(106)$ , which is always very narrow, was described by Buchrucker<sup>16</sup> in 1891 although it had probably been observed before.<sup>17</sup>

$\sigma(221)$ ,  $g(103)$ ,  $y(122)$ ,  $b(010)$ , and  $v(324)$  are all narrow, but afford signals which are fairly good.

$\Delta_1(109)$ ,  $\Sigma(1.0.11)$ ,  $(3.0.29)?$ , and  $(3.0.31)?$ , all of which are new forms, appeared but once as very narrow faces on crystal 1. These forms probably represent a type of oscillatory striation, since small reëntrant angles are formed between adjacent faces. Three different readings at three different times gave the following angles:

Face	1	2	3	Average
109	8°26'	8°26'	8°27'	8°26½'
1.0.11	10°24'	10°23'	10°22'	10°23'
3.0.29	9°40'	9°41'	9°41'	9°40½'
3.0.31	8°58'	8°59'	9°02'	9°00'

The signals from  $\Delta_1$  and  $\Sigma$  were fair, and the three readings agree very favorably with the calculated values. (See Table 2.) The signals from 3.0.29 and 3.0.31, however, were poor and somewhat blurred. Although the three readings did not greatly vary, and the average value closely agrees with the calculated angles, it would probably be best to consider them doubtful forms.  $(3.0.29)?$  and  $(3.0.31)?$  probably represent symmetrical vicinal replacements of the form (1.0.10) first doubtfully observed by Panebianco.<sup>18</sup> From this form the vicinal planes are removed about 20'.

In conclusion the author wishes to express his appreciation to Dr. James E. Maynard and other members of the Department of Geology at Syracuse University, and to Professor Charles Palache of Harvard University, for their assistance in the preparation of this article.

<sup>16</sup> Buchrucker, *ibid.*

<sup>17</sup> Personal communication from Professor Charles Palache, Jan. 30, 1934.

<sup>18</sup> Panebianco, R., *Krystallformen von Vicentiner Cölestin: Att. Soc. Veneto*, vol. 9, p. 1, 1884. Through abstract in *Zeit. f. Kryst.*, vol. 11, p. 400, 1886.



## AGE AND DISTRIBUTION OF PEGMATITES

KENNETH K. LANDES, *University of Kansas.*

(Continued from page 105)

### EUROPE

ENGLAND. Principal localities: Southwestern England (especially Devon, Cornwall, and Scilly Isles), Lundy Island, Isle of Man, and North of England. Types of pegmatite: Granite simple and complex and quartz monzonite complex. Granite pegmatites in Cornwall have ore minerals (including compounds of tin, tungsten, and molybdenum) and beryllium phases. Ore mineral phase also present at Carrock Fells, North of England. Lundy Island pegmatites have topaz and beryl phase. Quartz vein phase is present near Foxdale, Isle of Man. Pegmatites on Dartmoor are quartz monzonite with free gold phase.

REFERENCES: Brammall, A., and Harwood, H. F., The occurrence of a gold-bearing pegmatite on Dartmoor: *Mineral. Mag.*, vol. 20, no. 105, pp. 201-211, 1924. Davison, E. H., The variation in the composition of Cornish granites and its relation to the occurrence of tin lodes: *Trans. Roy. Geol. Soc. Cornwall*, vol. 16, no. 1, pp. 11-14, 1928. Finlayson, A. M., Ore-bearing pegmatites of Carrock Fells: *Geol. Mag.*, new ser., vol. 7, pp. 19-28, 1910. Lomas, J., Quartz dikes near Foxdale, Isle of Man: *Geol. Mag.*, new ser., decade 4, vol. 10, pp. 34-36, 1903. McIntock, W. F. P., and Hall, T. C. F., On topaz and beryl from the granite of Lundy Island: *Mineral. Mag.*, vol. 16, pp. 294-301, 1912. Osman, Chas. W., The granites of the Scilly Isles and their relation to the Dartmoor granites: *Quart. Jour. Geol. Soc. London*, vol. 84, no. 2, pp. 258-292, 1928.

SCOTLAND. The pre-Cambrian gneissic rocks of the Scottish Highlands and the islands to the northwest abound with simple granite and granodiorite pegmatites. Beryl is present in a pegmatite at Rubislaw, near Aberdeen.

REFERENCES: Barrow, George, On an intrusion of muscovite-biotite gneiss in the South-Eastern Highlands of Scotland: *Quart. Jour. Geol. Soc. London*, vol. 49, pp. 330-356, 1893. MacGregor, A. G., and Kennedy, W. Q., The Morvern-Strontian "Granite": *Summary of Progress of Geol. Survey for 1931*-Pt. II, pp. 105-119, 1932. Read, H. H., A diopside-bearing pegmatite near Ellon in Aberdeenshire: *Trans. Edinburgh Geol. Soc.*, vol. 11, pp. 353-356, 1925; The geology of Central Sutherland (Sheets 108 and 109): *Geol. Survey Scotland, Mem.*, 1931. Stewart, Malcolm, Notes on the geology of Sula Sgeir and the Flannan Islands: *Geol. Mag.*, vol. 70, no. 825, pp. 110-116, March, 1933.

IRELAND. Localities: Carlingford-Mourne Mts. district of Louth and Down counties, and vicinity of Killiney, near Dublin. Types

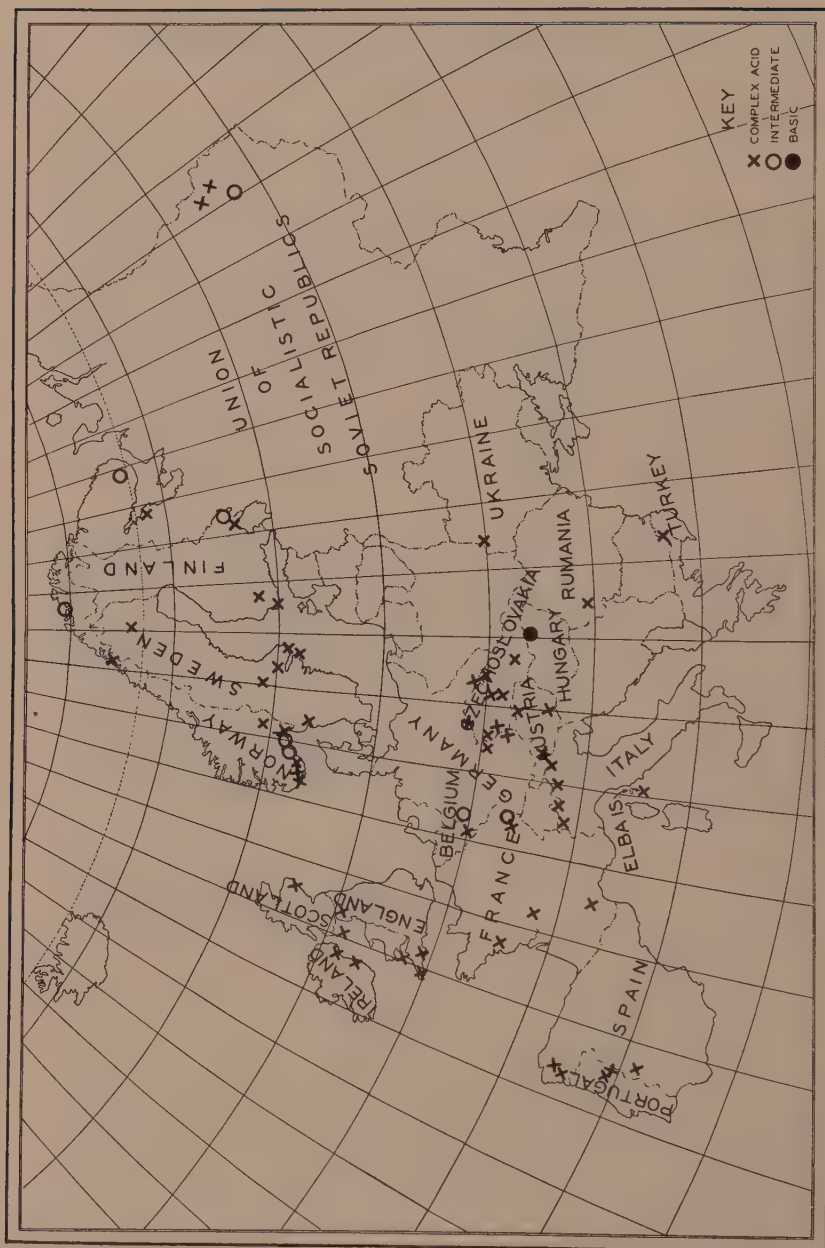


PLATE III. Distribution of complex acidic, intermediate, and basic pegmatites in Europe.



of pegmatite: Granite simple and complex. Latter have a beryllium phase in Mourne Mts. and at Killiney.

REFERENCES: Delesse, A., Sur la Pegmatite de l'Ireland: *Bull. Soc. Geol. de France* (2), vol. 10, pp. 568-588, 1853. Osborne, G. D., The metamorphosed limestones and associated contaminated igneous rocks of the Carlingford district, Co. Louth: *Geol. Mag.*, vol. 69 (815), pp. 209-233, 1932.

NORWAY. Principal localities: The southern Norwegian coastal zone extending from the Swedish boundary to beyond Hittero (including Moss, Kragero, Risor, Arendal, and Iveland) and the northern coast from Trondhjem to North Cape. Types of pegmatite: Granite simple and complex and intermediate complex. Granite pegmatites with a rare-earth mineral phase at Moss, Kragero, Arendal, Iveland, Hittero, and many other southern Norwegian localities. Beryllium phase at Iveland and Minne (northeast of Oslo). Molybdenite phase at Kvina and Knaben mines, southern Norway. Fluorine phase at Hundholmen and Drag (68° N). Syenite and nephelite syenite pegmatites abundant between Christianafjord and Langesundfjord. Dioritic pegmatites occur at Kragero. Complex nephelite syenite pegmatites are found on Seiland, an island in Arctic Norway.

REFERENCES: Andersen, Olaf, Feldspat I: *Norway Geol. Survey*, no. 128 A, 57 pp., 1926; Feldspat II and III (latter by Barth): *Norway Geol. Survey*, no. 128 B, pp. 1-154, 1931. (Norwegian with English summary). Andersen, Olaf, Discussion of certain phases of the genesis of pegmatites: *Norsk. Geol. Tidsskr.*, vol. 12, pp. 1-56, 1931. Abstract in *Annotated Bibliography of Econ. Geology*, 4, no. 2, 192. Barth, Tom, Die Pegmatitgänge der Kaledonischen Intrusivgesteine im Seiland-gebiete: *Skrifter Norske Vidensk. Akad.*, p. 123, 1927, [I Mat. Naturv. Klasse, No. 8, Oslo (Jacob Dybwad)]. Reviewed by Knopf in *Am. J. Sci.*, pp. 272-273, March, 1928. Björlykke, Harald, Norwegische Mikrolithminerale: *Norsk. Geol. Tidsskr.*, vol. 14, pp. 145-161, 1933. Brögger, W. C., Die Mineralien der Syenitpegmatitgänge der Südnorwegischen Augit- und Nephelinsyenite: *Zeit. Kryst.*, vol. 16, 1890. Brögger, W. C., Die Mineralien der Südnorwegischen Granitpegmatitgänge, I: *Vid.-elsk. Skr., Math. Nat. Kl.*, no. 6, 1906. Goldschmidt, V. M., Die Contactmetamorphose in Kristiania Gebiet: *Skrifter utgitt av Videna, i. Kristiana (Mat.-Natur. Kl.)*, 1911 (pub. 1912). Hoel, Adolf, and Schetelig, J., Nephelite-bearing pegmatite dikes in Seiland: *Festskrift, Armund Helland, Kristiana*, pp. 110-131, 1916, Abstract in *Mineral. Abstracts*, 1, p. 282. Vogt, J. H. L., The physical chemistry of the magmatic differentiation of igneous rocks: *Skrifter utgitt av Det Norske, Videnskaps-Akademi i Oslo*, no. 3, First half, pp. 1-131, 1929; *I. Mat.-Naturv. Klasse*, Second half, pp. 1-242, 1930. Woakes, Ernest R., Molybdenite in Norway: *Trans. Inst. Min. and Met.*, vol. 27, pp. 184-195, Jan. 17, 1918.

SWEDEN. Exposures of crystalline rocks cover almost all of Sweden. Principal pegmatite districts: West coast, from Norwegian

boundary south to Göteborg, including the localities of Nohl, Trollhättan, and Bohuslän; the south of Sweden; the vicinity of Stockholm and the region to the north and west, including the localities of Üto, Ytterby, Broddbo, Finbo, and Mansjö Mt.; and the mining district of far northern Sweden. Types of pegmatite: Mainly granite simple. Complex with rare earth mineral phase at Nohl, Ytterby, and Broddbo; lithium phase at Üto; beryllium phase at Finbo; and iron ore (magnetite) phase at Gellivarre, northern Sweden.<sup>38</sup>

REFERENCES: Eckerman, Harry von, The rocks and contact minerals of the Mansjö Mt.: *Geol. För. Förh. Stockholm*, vol. 44, pp. 203–410, 1922. Abstract in *Mineral. Abstracts*, 1, pp. 396–397. Johansson, H. E., Om Svenska kvarts-och fältspatförekomster: *Geol. Fören. Förh.*, vol. 36, pp. 116–129, 1915. Loostroem, R., Pegmatitgang i Getlycke: *Geol. För. Förh. Stockh.*, vol. 52, pp. 431–434, 1930. Nordenskjöld, Iver, Der Pegmatit von Ytterby: *Bull. Geol. Inst. Univ. Upsala*, vol. 9, pp. 183–228, 1910.

FINLAND. Pegmatites are abundant throughout Finland. Important localities are Carelia (east Finland), northern shore of Lake Ladoga, and the Kimito Island vicinity and Tammela in southwestern Finland. Types of pegmatite: Mostly granite simple. Granite complex with rare earth mineral phase at Lake Ladoga, lithium and beryllium phases at Tammela, and beryllium, phosphate, and minor fluorine, tantalum, and ore mineral phases on southwestern coast. Uuksu (Carelia) pegmatite a rare type, probably a syenite, with beryllium phase.

REFERENCES: Eskola, P., On the petrology of the Orijärvi Region, etc.: *Bull. Comm. Géol. Finlande*, no. 40, pp. 1–277, 1914. Krancke, E. H., A beryl-bearing pegmatite from Uuksu in Carelia, east Finland: *Bull. Comm. Géol. Finlande*, no. 85, pp. 70–77, 1929. Abstract in *Mineral. Abstracts*, 4, no. 7, pp. 328–329. Lokka, Lauri, Über Wiikit: *Bull. Comm. Géol. Finlande*, no. 82, p. 68, 1928. Abstract in *Mineral. Abstracts*, 4, no. 6, p. 249. Makinen, Eero, Die Granitpegmatite von Tammela in Finnland und ihre Minerale: *Bull. Comm. Géol. Finlande*, vol. 35, pp. 1–101, 1913.

RUSSIA. Pegmatites occur in three widely separated districts: (1) The Fennoscandian Shield which extends into northwestern Russia (Carelia and Kola Peninsula); (2) the intrusive rock belt of Volhynia in southwestern Russia (Ukraine); and (3) the Ural Mountains, both north and south of Ekaterinburg. Types of pegmatite: Granite and syenite simple and complex. Granite pegmatites have a rare earth mineral phase in belt lying west of White Sea (Carelia) and in Volhynia. Beryllium, boron, and other phases

<sup>38</sup> Ries, H., Personal communication dated June 5, 1933.

present in pegmatites of Ekaterinburg-Mursinka district, Ural Mountains. The southern Urals (Ilmen Mts.) contain complex syenite pegmatites. Nephelite syenite pegmatites with a rare alkaline mineral phase occur on Kola Peninsula.

REFERENCES: Omelandov, A., Industrial evolution of the Vishnegorsk feldspar deposit: *U.S.S.R. Geol. and Prosp. Service, Bull.* **43**, pp. 685-706, 1931. (English summary pp. 704-706). Abstract in *Annotated Bibliography of Econ. Geology*, **5**, 1, 520. Fersman, A. E., Sur les tantaloniobates de l'Oural d'Ekaterinburg: *Compt. rend. Acad. Sci. Russie*, pp. 10-12, **1925**, Abstract in *Mineral. Abstracts*, no. **3**, p. 103, 1926. Fersman, A. E., Sur l'âge de l'uraninite dans les filons de pegmatite: *Bull. Acad. Sci. U.S.S.R.*, vol. **20**, pp. 775-780, 1926. Abstract in *Mineral. Abstracts*, no. **3**, p. 263, 1927. Fersman, A. E., Ueber die Natur der Pegmatitbildungen: *Compt. Rend. Acad. Sci. Russie*, pp. 89-92, **1924**, Abstract in *Mineral. Abstracts*, no. **2**, p. 399. Grigorev, P. K., Uranium pitchblende in northern Karelia: *Botschafter Geol. Komitëls*, no. **1**, pp. 33-34, 1925. Abstract in *Mineral. Abstracts*, no. **3**, p. 146, 1926. Labuntzov, A. N., Sur la découverte des gisements d'ouranates dans la Carélie russe: *Compt. Rend. Acad. Sci. Russie*, pp. 113-114, **1925**. Abstract in *Mineral. Abstracts*, no. **3**, p. 107. Piatnitsky, P., Geological explorations in the emerald district in the Urals: *Trans. Geol. and Prosp. Service U.S.S.R.*, Fascicle **75**, pp. 1-71, 1932. (English summary pp. 68-71).

POLAND. Simple granite pegmatites occur in the Sarny district of eastern Poland at the northwestern extremity of the Volhynian intrusive rock belt.

REFERENCE: Chlipalska, Eugenja Zaniewska, Contrib. a l'étude des filons pegmatiques et aplitiques des environs de Klesowo (Pologne): *l'Archive du Lab. de Min. de la Soc. des Sciences de Varsovie*, vol. **1**, pp. 174-183, 1923.

GERMANY. Principal localities: The mountainous zone bordering Czechoslovakia between south-central Silesia and the Danube, including south-eastern Saxony (the Erzgebirge) and northeastern and eastern Bavaria (the Fichtelgebirge, Oberpfälzer Wald, and Bayrischer Wald). Also in the vicinity of Laacher See, near Coblenz. Types of pegmatites: Alkaline syenite with calcite phase at Laacher See; elsewhere granite simple and complex. Beryllium phase exhibited in a number of pegmatites in Silesia, Erzgebirge, and Bayrischer Wald. Phosphate phase in Oberpfälzer Wald (several localities) and in Bayrischer Wald. Ore mineral (especially cassiterite) and lithium phases in vicinity of Zinnwald in the Erzgebirge.

REFERENCES: Laubmann, H. und Steinmetz, H., Phosphatführende Pegmatite des Oberpfälzer und Bayerischen Waldes: *Zeit. Kryst.* vol. **55**, pp. 523-586, 1915-1920. Abstract in *Mineral. Abstracts*, no. **1**, pp. 124-125. Müllbauer, F., Die Phosphatpegmatite von Hagendorf i. Bayern: *Zeits. Krist.*, vol. **61**, pp. 318-336, 1925.



Abstract in *Mineral. Abstracts*, no. 2, p. 417. Müllbauer, F., Die Pegmatit und Kontaktlagerstätte am Wimhof bei Vilshofen a. d. Donau in Bayern: *Centr. f. Min.*, pp. 96–112, 1930-A, Schuster, Ernst, Calcitführende Auswürflinge aus dem Laacher Seegebiet: *Neues Jahrb. Min., Beil.-Bd.* 43, pp. 295–318, 1919. Abstract in *Mineral. Abstracts*, no. 2, p. 123.

BELGIUM. Veins of plagioclase, biotite, and quartz with subordinate xenotime and yttracrasite in the Bastogne region of south-eastern Belgium are considered by Corin to be pegmatites.

REFERENCE: Corin, F., Contrib. a l'étude pétrographique des filons de la région de Bastogne: *Bull. Acad. Roy. Cl. Sci.*, 5th ser., t. XVI, no. 2, 1 fevr. 1930, pp. 130–134; Sur la présence de xenotime et d'autres minéraux contenant des terres rares dans les veines a bastonite de Bastogne: *Bull. Soc. Belge de Geol.*, t. XLI, 1 fev.-28 avr., pp. 109–111, 1931. Abstract in *Rev. Geol.*, vol. 13, fasc. 1, pp. 11–12, 1923–33.

FRANCE. Principal localities: Three areas in France contain crystalline rocks in which pegmatites occur. These are the hercynienne Vosge of northeastern France; Brittany; and the Central Plateau. Types of pegmatite: Mainly granite, both simple and complex. Latter exhibit an ore mineral phase in the southern part of the hercynienne Vosge, an ore mineral and beryllium phase near Nantes in Brittany, a lithium and beryllium phase near Brassac in the southern part of the Central Plateau, and lithium, beryllium, tin, and antimony phases in the region surrounding Limoges (Haute-Vienne) in the northern part of the Central Plateau. Lime-alkaline pegmatites cut calcareous rocks in the hercynienne Vosge of Alsace.

REFERENCES: Arsandaux, H., Sur quelques minéraux des environs de Brassac (Tarn): *Bull. Min. Soc. Fran.*, vol. 24, pp. 428–432, 1901. Abrard, René, Présence de l'apatite dans les pegmatites des environs de Dinard: *Bull. Min. Soc. France*, vol. 46, p. 5, 1923. Abstract in *Mineral. Abstracts*, no. 3, p. 54. De Launay, M. L., Excursion a quelques gîtes minéraux et métallifères du Plateau Central: *Extrait du Compte-Rendu du VIII<sup>e</sup> Congrès Géologique International (Paris)*, pp. 10 et seq., 1901. Jung, Jean, Contribution a la géologie des Vosges hercyniennes d'Alsace: *Mem. Serve. Carte. Geol. Alsace et Lorraine*, no. 2, pp. 1–481, 1928. Karpinski, R. W., Contrib. a l'étude métallogénique des Vosges méridionales, Nancy, pp. 1–142, 1931. Abstract in *Annotated Bibliography of Econ. Geology*, 4, no. 2, p. 216. Rastall, R. H., Molybdenum ores: *Monograph, Imperial Inst.*, pp. 1–86, 1920.

PORTUGAL. Localities: Scattered over the area of outcrop of the Sierra da Estrella Massif in the provinces of Beira Alta and Beira Baixa, northern Portugal. Guarda and Mangualda are cities within the district. Types of pegmatite: Granite. Pegmatites are complex, exhibiting lithium, beryllium, tin and tungsten, and rare earth mineral phases at several localities.

REFERENCES: Dittmann, Adolf, Kurze Mitteilungen über Zinnerz-Lagerstätten in Spanien und Portugal: *Metall u. Erz.*, vol. 30 (1), pp. 6–10, Jan. 1933. Abstract in *Annotated Bibliography of Econ. Geology*, 6, 1, 325. Duparc, L., and Gysin, M., Notices minéralogiques les minéraux de la pegmatites de Mangualde: *Schweiz. Min. Petr. Mitt.*, vol. 7, pp. 32–34, 1927. Abstract in *Mineral. Abstracts*, 4, 7, p. 328.

SPAIN. Two pegmatite districts: (1) The Paleozoic granite area of western Spain (east of the Portuguese boundary), and (2) the provinces of Pontevedra and southern Coruna in northwestern Spain north of the Portuguese boundary. Types of pegmatite: Granite simple and complex. Latter have a beryllium phase in northwestern Spain, a tin, tungsten and lithium phase near Caceres and elsewhere in western Spain, and a lithium phase at Lalin, Pontevedra.

REFERENCES: Gibson, W. B., A new occurrence of spodumene: *Rocks and Minerals*, vol. 7, no. 1, p. 23, 1932. Krusch, P., Die Beziehungen der Wolframit- und Bleierzlagerstätten Westspaniens zu Graniten und zur Tektonik: *Zeit. Deut. Geol. Ges.*, Monatsb., vol. 80 (1–2), pp. 34–46, April 10, 1928. Abstract in *Annotated Bibliography of Econ. Geology*, no. 210, 1928.

ITALY. Principal localities: The Italian Alps, adjacent to the Swiss and Austrian boundaries, and on the island of Elba. Types of pegmatites: Granite simple and complex. A beryllium phase occurs at a number of localities, including Mount Velan in northwestern Piedmont, Lake Maggiore district, northern Lombardy, the Sarntaler Alps near Meran in Trentino, and S. Pietro and S. Ilario on the island of Elba. Rare earth minerals occur in pegmatites in northern Piedmont and Lombardy. A prominent gem tourmaline phase occurs on Elba.

REFERENCES: Cornelius, H. P., Ueber Auftreten und Mineralführung der Pegmatite in Veltlin und seinen Nachbartälern: *Centr. f. Min., Abt. A.*, pp. 281–287, 1928. Abstract in *Annotated Bibliography of Econ. Geology*, 2, 2, p. 224. Dittler, E., Neue Beryllaufschlüsse in der Mosullschlucht, Südtirol: *Tschermak Min. Petr. Mitt.* vol. 40, pp. 188–189, 1930.

SWITZERLAND. Simple granite pegmatites occur at several localities north of the Italian boundary in the provinces of Tessin and Grison.

AUSTRIA. Pegmatites are fairly numerous in the Tyrolean and Eastern Alps extending from western Austria through Carinthia and western Styria to central Styria. Also on the southern edge of the Bohemian massif in northern (Upper) Austria. Types of pegmatite: Granite simple and complex. Beryllium phase present

at Habachthal (western Austria) and elsewhere in the Tyrol, Zissingdorf near Freistadt (northern Austria), and in the vicinities of Köflach and Graz in Styria. Lithium phase also present near Graz. Pegmatites with a sulphide ore mineral phase occur on the boundary between Carinthia and Styria.

REFERENCES: Angel, Franz, Spodumen und Beryll aus dem Pegmatiten von St. Radegund bei Graz: *Tschermak Min. Petr. Mitt.*, vol. 43, pp. 441-446, 1933. Abstract in *Mineral. Abstracts*, 5, no. 6, p. 288. Friedrich, O., Eine alte pegmatitische Erzlagerstätte der Ostalpen: *Neues Jahrb., Beil.-Bd.* vol. 65, Abt. A, (3), pp. 479-508, 1932. Abstract in *Annotated Bibliography of Econ. Geology*, 5, (2), no. 251. Tornquist, A., Alpine Berylliumerzlagerstätten: *Metall. u. Erz.*, vol. 27, no. 7, pp. 177-179, 1930. Abstract in *Annotated Bibliography of Econ. Geology*, 3, 1, 631.

CZECHOSLOVAKIA. Principal districts: Pegmatites are widely scattered over Bohemia and western Moravia. Also found in Czech Silesia and Middle Slovakia. Types of pegmatite: Granite simple and complex. A lithium phase is found on the Bohemian side of the Erzgebirge (near Zinnwald, Saxony), at Schüttenhofen (south-western Bohemia), and at Rozna, Puklice (with beryl, cassiterite, and tungsten minerals) and elsewhere in western Moravia. A beryllium phase is present at a number of localities, including Pisek in Bohemia, Budislav (with sulphide ore minerals) in western Moravia, and in the Zjargebirge of Middle Slovakia. Pegmatites with a phosphate phase occur near Marienbad and Ronsberg, western Bohemia, and Pribyslavice in eastern Bohemia. Rare earth minerals occur near Pisek, Horky (eastern Bohemia), and Friedeberg in Czech Silesia.

REFERENCES: Fiala, Fr., Einige mineralogische Funde aus dem Gebirge von Zjar: Abstract in *Neues Jahrb.*, Ref. 1, 6 Heft, p. 519, 1932. Jarös, Zdeněk, New locality for lepidolite and associated minerals in western Moravia; The minerals of pegmatite boulders from Puklice near Jihlava. Abstracts in *Mineral. Abstracts*, 3, pp. 547-548. Kratochvil, Fr., *Mineralogische Beiträge*: Abstract in *Neues Jahrb.*, Ref. 1, 6 Heft, p. 519, 1932. Kratochvil, J., Supplement to the topographic mineralogy of Bohemia for the years 1930-31: Abstract in *Mineral. Abstracts*, 5, no. 6, p. 271-2. Nováček, R., Minerals of the pegmatites and surrounding rocks from Budislav in eastern Bohemia: Abstract in *Mineral. Abstracts*, 4, no. 1, p. 41. Sekanina, Josef, The Minerals of the Moravian pegmatites: Abstract in *Mineral. Abstracts*, 4, no. 1, p. 42; L'excursion mineralogique a Nedvedice et Rozna en Moravie occidentale: Abstract in *Rev. de Geologie*, 12, fascicle 1, p. 30. Sellner, Fritz., Die Pegmatite der Umgebung von Marienbad: *Zeit. Kryst.*, vol. 59, pp. 504-512, 1924; vol. 60, pp. 275-277, 1924. Abstract in *Mineral. Abstracts*, no. 2, p. 472. Ulrich, Frantisek, Two new finds of orthite from Czech countries: Abstract in *Mineral. Abstracts*, 5, no. 6, p. 271.

HUNGARY. Basic pegmatites occur in a gabbroidal mass at Szarvoska in the Bükk Mts.



REFERENCE: Szentpétery, S. V., Oligoklasgesteine der Gegend von Szarvasko: *Mat. Term-tud. Ertesitö, Budapest*, vol. 47, pp. 466-467, 1930. Abstract in *Mineral. Abstracts*, no. 4, p. 510.

YUGOSLAVIA. Muscovite pegmatites occur among the crystalline rocks of the Rhodope massif in the vicinity of Vranje, south Serbia.

RUMANIA. Pegmatites occur in the Transylvanian Alps in south-central and southwestern Rumania. A beryllium phase is present at Teregova in Banat.

REFERENCES: Rotman, D., *Bull. Sect. Sci. Acad. Româniă*, vol. 7, (for 1920-21), pp. 90-96, 1921. Abstract in *Mineral. Abstracts*, no. 2, p. 130. Dittler, E., and Kirnbauer, F., Ueber das neue Beryllvorkommen von Teregova in Rumanien: *Z. prakt. Geol.*, vol. 39 (4), pp. 49-56, 1931. Abstract in *Annotated Bibliography of Econ. Geology*, 4, 1, 517.

TURKEY-IN-EUROPE. Uraninite occurs in a pegmatite near Adrianople.

#### AFRICA

ABYSSINIA. Muscovite pegmatites occur in the Harrar district of eastern Abyssinia.

REFERENCE: Bordeaux, Albert, Gisements de Mica en Ethiopie: *Mines Carrieres*, vol. 9, pp. C97-105, Sept. 1930. Abstract in *Annotated Bibliography of Econ. Geology*, 3, 2, p. 575.

BRITISH SOMALILAND. Muscovite pegmatites have been found on the Mirsa Plateau and in the Golis range, west-central British Somaliland. A beryllium phase is present in deposits on the Mirsa Plateau.

KENYA COLONY. Mica has been mined from granite pegmatites found on the slopes of Mount Kenya in central Kenya and from the vicinity of Sultan Hamud in the south-central part of the Colony.

UGANDA. Pegmatites common in the pre-Cambrian rocks of this province, especially west and north of Lake Victoria. Types: Granite simple and complex, with tin, beryllium, and lithium phases. Tin and beryllium phases best developed in Ankole district of southwestern Uganda, extending into the northeast corner of Belgian Ruanda, and the northwest corner of Tanganyika.

REFERENCES: Combe, A. D., The geology of southwestern Ankole and adjacent territories with special reference to the tin deposits: *Uganda Geol. Survey, Mem.* 2,

pp. 1-236, 1932. Prior G. T., Contributions to the petrology of British East Africa: *Mineral. Mag.*, vol. 13, pp. 228-263, 1903. Stheeman, H. A., The geology of south-western Uganda, with special reference to the stanniferous deposits, *The Hague*, pp. 1-144, 1932. Abstract in *Annotated Bibliography of Econ. Geology*, 5, 1, no. 406.

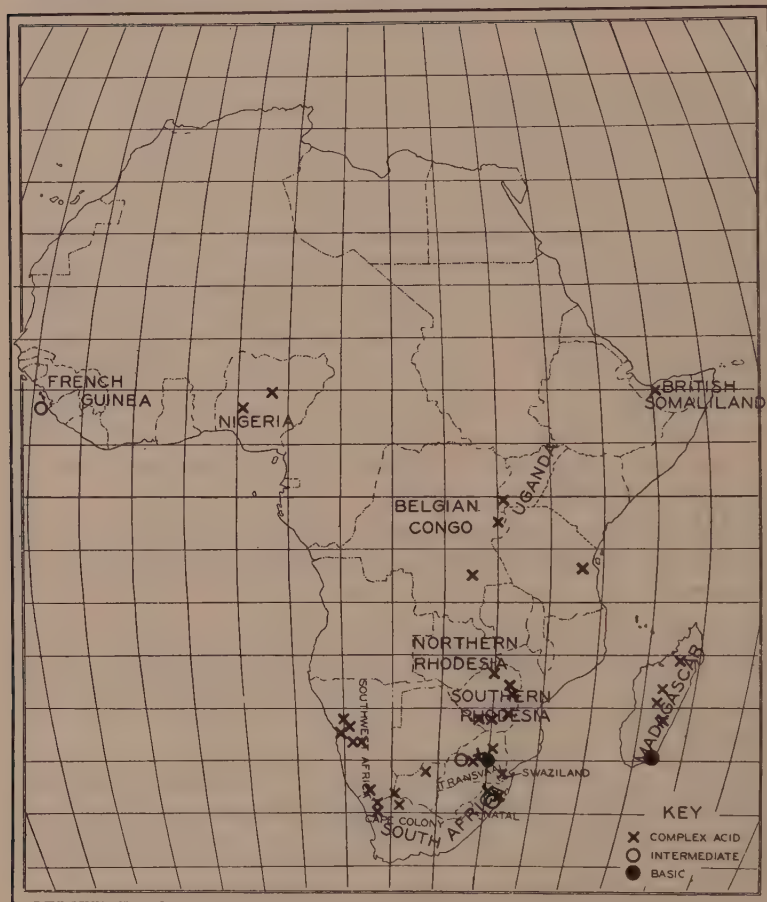


PLATE IV. Distribution of complex acidic, intermediate and basic pegmatites in Africa.

**BELGIAN CONGO.** Granite pegmatites occur in the north-south belt of pre-Cambrian rocks which lies between the upper Congo (and its tributary Lualaba River) and Urundi-Ruanda and Lake Tanganyika. A tin phase is present in Urundi-Ruanda and at Manono, which lies 53 km. east of the river Lualaba.

REFERENCES: Aubel, René von, Sur quelques minéraux du Congo Belge: *Soc. Géol. Belgique, Ann. Publ. rel. Congo Belge*, vol. 53 (2), pp. C77-79, 1931. Fontainas, Paul, and Ansotte, Max, Perspectives minières de la région comprise entre le Nil, le Lac Victoria et la Frontière Orientale du Congo Belge: *Inst. Royal Colonial Belge, Mem.* 1 (5), pp. 3-27, 1932. Abstract in *Annotated Bibliography of Econ. Geology*, 5, 1, no. 407. Scott, R. W., Katanga tin properties: *Mineral. Mag.*, vol. 46 (1), pp. 24-27, 1932.

TANGANYIKA. Muscovite pegmatites are fairly abundant in the crystalline rocks of east-central and northeastern Tanganyika, especially in the Uluguru and Nguru Mts. and in Westusambara. A rare earth mineral phase is developed in pegmatites in the Uluguru Mts. near Morogoro.

REFERENCE: Teale, E. O., Tanganyika territory; its geology and mineral resources: *Mineral. Mag.*, vol. 38, pp. 331-338, 1928; vol. 39, pp. 9-17, 75-82, 1928.

NYASSALAND. Mica pegmatites occur in the large granite exposure southwest of Lake Nyassa and in smaller areas of granite outcrop south of the lake, and near the northern end of the Protectorate.

NORTHERN RHODESIA. Mica pegmatites have been exploited in the Susoka district.

SOUTHERN RHODESIA. Pegmatites are widely scattered over the pre-Cambrian terrain which covers most of southern Rhodesia. Types: Granite simple and complex. A lithium phase is present in the Antelope gold belt south of Bulawayo, near Salisbury and Odzi (Umtali district) in the eastern part of the territory, in the Victoria tin field, and in the Belingwe district in the southern part of the territory. A beryllium phase is present in the Lomagundi mica district in northern Southern Rhodesia.

REFERENCES: Phaup, A. E., The geology of the Antelope gold belt; *Geol. Survey Southern Rhodesia*, Bull. 21, 119 pp., 1932. Tyndale-Biscoe, R., Report on the geology of part of the Salisbury gold belt: *Southern Rhodesia Geol. Survey*, Bull. 19, pp. 1-39, 1932.

MOZAMBIQUE. Simple granite pegmatites occur within the pre-Cambrian rocks of this territory.

REFERENCE: Holmes, Arthur, The pre-Cambrian and associated rocks of the district of Mozambique: *Quart. Jour. Geol. Soc. London*, vol. 74 (for 1918), pp. 31-98, 1919. Abstract in *Mineral. Abstracts*, no. 1, p. 92.

UNION OF SOUTH AFRICA. Four provinces in the Union contain pegmatites. These will be considered separately.



TRANSVAAL. Pegmatites are fairly abundant in the crystalline complexes of northern and eastern Transvaal. Types of pegmatite: Granite simple and complex, alkaline syenite, and basic complex. Complex granite pegmatites with a tin phase are well developed in the Waterberg tin fields, especially in the Bushveld complex northwest of Potgietersrust. A beryllium phase is present in pegmatites of the Leydsdorp district. Platinum minerals occur at Tweefontein, and in basic pegmatite in the Lydenburg district. The Pilandsberg district contains syenite pegmatite with a rare alkaline mineral phase.

REFERENCES: Brouwer, H. A., On the geology of the alkaline rocks in the Transvaal: *Jour. Geology*, vol. 25, pp. 741-778, 1917. Hall, A. L., Mica in the Eastern Transvaal: *Union of S. Africa, Dept. of Mines and Industries, Geol. Survey, Mem.* 13, 1920. Hall, A. L., The Palabora plutonic complex of the Low Country and its relationship to the pegmatites of the Leydsdorp mica fields: *Trans. Geol. Soc. S. Africa*, vol. 15, pp. 4-17, 1913. Kynaston, H., The geology of the country north and northwest of Potgietersrust: *Pret. Ann. Rept. Geol. Survey Transvaal for 1908*, pp. 11-23, 1909. Kynaston, H., and Mellor, E. T., The geology of the Waterberg tin-fields: *Geol. Survey of Transvaal, Mem.* 4, 1909. Le Grange, J. M., The Barbara beryls, etc.: *Trans. Geol. Soc. S. Africa*, vol. 32 (for 1929), pp. 1-25, 1930. Wagner, P. A., The Potgietersrust cassiterite pipes: *S. A. Min. Eng. Jour.*, vol. 1839, pp. 473-474, 1926. Wagner, P. A., and Mellor, E. T., On platinum-bearing hortonolite dunite of the Lydenburg district: *Trans. Geol. Soc. S. Africa*, vol. 28, pp. 1-18, 1925. Wagner, P. A., and Reinecke, Leopold: *Mineral deposits of the Union of South Africa*, 282 pp., 1930.

SWAZILAND. Northern Swaziland contains a granite pegmatite dike with a tin phase.

REFERENCE: Bond, G. W., Notes on the mineralized belt of Jamestown series, Forbes Reef, northern Swaziland: *Trans. Geol. Soc. S. Africa*, vol. 32 (for 1929), pp. 177-186, 1930.

NATAL. Simple granite pegmatites are abundant in Zululand, especially in the Umfuli, Mvuzana, and Tirgela valleys. Complex granite pegmatites with a tin phase occur in the Umfuli Valley east of Melmoth, and a molybdenite phase is found in Buffalo Valley. A corundum-bearing pegmatite occurs near Krantz Kop.

REFERENCES: Hatch, F. H., *Report on the mines and mineral resources of Natal*, London, pp. 1-151, 1910. du Toit, A. L., Plumasite (corundum-aplite) rocks from Natal: *Trans. Geol. Soc. S. Africa*, vol. 21, pp. 53-62, 1918.

CAPE COLONY (and British Bechuanaland). The northwestern portion of this province is floored with pre-Cambrian crystalline rocks in which pegmatites are abundant. Districts: Namaqualand

and Kenhardt in Cape Colony proper; Gordonia and Mafeking (north of Vryberg) in British Bechuanaland. Types of pegmatite: Granite simple and complex. Jackals Water, northeast of Steinkopf in Namaqualand contains pegmatites exhibiting beryllium, lithium, and rare earth mineral phases. A rare earth mineral phase is also present in many pegmatites outcropping in the Kenhardt and Gordonia districts. An ore mineral phase is found in pegmatites in all four districts, including the pegmatites associated with the copper veins of Ookiep in Namaqualand.

REFERENCES: Behrend, Fritz, Uranerzführende Pegmatitgänge in Südafrika und ihre Geochemie: *Archiv. f. Lagerstättenforschung*, **H. 54**, pp. 1–36, 1933. Abstract in *Annotated Bibliography of Econ. Geology*, **6**, 1, 354. Kovaloff, P., Notes on beryl occurrences in Namaqualand: *Int. Geol. Cong. Compte Rendu*, vol. **2**, pp. 439–443, 1929. Mountain, E. D., Pegmatites of the Cape Province: *Rec. Albany Mus., Grahamstown*, vol. **4**, pp. 122–144, 1931. Rogers, A. W., Notes on the occurrence of radioactive minerals in South Africa: *Trans. Geol. Soc. So. Africa*, vol. **18**, pp. 5–10, 1915; Report on a portion of Namaqualand: *Ann. Rept. So. Africa Geol. Survey*, pp. 127–151, 1912.

SOUTHWEST AFRICA. Pegmatites are exceptionally abundant (and exceptionally rich in accessory minerals) in the Erongo Mts.—Damaraland area, lying between Windhoek and the coast. They also occur to the south where Namaqualand extends into South-west Africa. Types of pegmatite: Granite simple and complex. A tin phase is very well developed in the Erongo Mts. and adjacent territory. Ores of copper and tungsten occur in pegmatites at many localities in Damaraland and in the southern part of the Protectorate. A lithium phase is present in the Erongo district and a beryllium phase near Rössing station which lies a short distance northeast of Swakopmund on the coast. Several of the Damaraland pegmatites exhibit a phosphate phase, and a tourmaline phase is present in a few Damaraland and Erongo localities. Pegmatites with a rare earth mineral phase occur northwest of the Erongo Mts. and in Damaraland and Namaqualand.

REFERENCES: Frommurze, T. W., and Gevers, H. F., *Int. Geol. Cong. 15th Session (So. Africa), Guidebook Excursion C 21*, 1929. Gevers, T. W., and Frommurze, H. F., The tin-bearing pegmatites of the Erongo area, South-West Africa: *Trans. Geol. Soc. S. Africa*, vol. **32** (for 1929) pp. 111–149, 1930. Abstract in *Mineral. Abstracts*, **4**, no. 9, pp. 411–412, 1931. Heinke, C., Pegmatitgänge in ehemaligen Deutsch-Südwestafrika: *Ber. Freiberg Geol. Ges.*, vol. **14**, pp. 12–14, April, 1933. Abstract in *Annotated Bibliography of Econ. Geology*, **6**, 1, no. 146. Kaiser, E., Ein Neues Beryll (Aquamarine) Vorkommen in Deutsch Südwestafrika: *Centralbl. f. Mineral.*, pp. 385–390, 1912. Kock, W. P. de., The lepidolite deposits of South-

West Africa: *Trans. Geol. Soc. South Africa*, vol. 35, pp. 97-113, 1932 (1933). Reuning, E., Die Natasmine in Südwest-Afrika, eine pegmatisch-pneumatolytisch-hydrothermale Übergangslagerstätte mit Scheelite, Molybdänglanz, Kupfererzen und Gold: *Neues Jahrb. f. Mineralogie*, Bd. 52, pp. 192-264, 1925. Reuning, E., Pegmatites and pegmatite mineralien in Southwest Africa: *Zeit. Kryst.*, vol. 58, pp. 448-459, 1923. Abstract in *Mineral. Abstracts*, no. 2, p. 167. Rimann, E., Zur Kenntnis Südwestafrikaner Kupfererzorkommen: *Zeit. f. prak. Geol.*, vol. 22, pp. 223-225, 1914. Wagner, P. A., The geology and mineral industry of Southwest Africa: *Union of South Africa, Geol. Survey, Mem.* 7, pp. 111, 1916.

FRENCH EQUATORIAL AFRICA. Simple granite pegmatites occur in the Gabon and western Kamerun districts.

REFERENCE: Brajnikov, B., Contribution à l'Étude petrographique du Mayombe Septentrional (Gabon): *Bull. Soc. Géol. Fr.*, ser. 5, t. II, pp. 379-392, 1932. Abstract in *Rev. Geology*, 13, no. 1305, 1932-1933.

NIGERIA. Granite pegmatites with a tin phase occur in the Nigerian tin fields in Ilorin and Nassarawa-Bauchi provinces.

FRENCH GUINEA. Sodalite-syenite on the island of Rouma contains syenite pegmatites with a rare alkaline mineral phase.

REFERENCE: Lacroix, A., Les pegmatites de la syénite sodalitique de l'île Rouma: *Compt. Rend. Acad. Sci. Paris*, vol. 192, pp. 189-194, 1931. Abstract in *Mineral. Abstracts*, 4 (11), p. 497.

MADAGASCAR. Pegmatites are abundant in the crystalline rocks which cover all of the island except that portion adjacent to the west coast. The more famous pegmatite localities are in the central part. Types: Granite simple and complex and basic complex. Pronounced lithium, beryllium, and tourmaline phases are present, and several other phases, such as rare earth minerals, are developed to a lesser extent in the complex granite pegmatites. Madagascar is noted for its pegmatite gem stones. Basic pegmatites with a phlogopite phase occur in the vicinity of Fort Dauphin in the extreme southeastern section of the island.

REFERENCES: Duclos, Aux Prospecteurs de Beryls: *Bull. Mines Madagascar*, no. 4, 76 pp., 1924. Abstract in *Rev. Geol.* 4, 628. LaCroix, Alfred, *Mineralogie de Madagascar, Paris, 1922.*

#### ASIA

ASIA MINOR. Simple granite pegmatites occur in the Batum-Artvin district of western Georgia, the Kulp district of central Armenia, and in the territory east of Suryma in Asiatic Turkey. Complex granite pegmatites with a beryllium phase occur in the



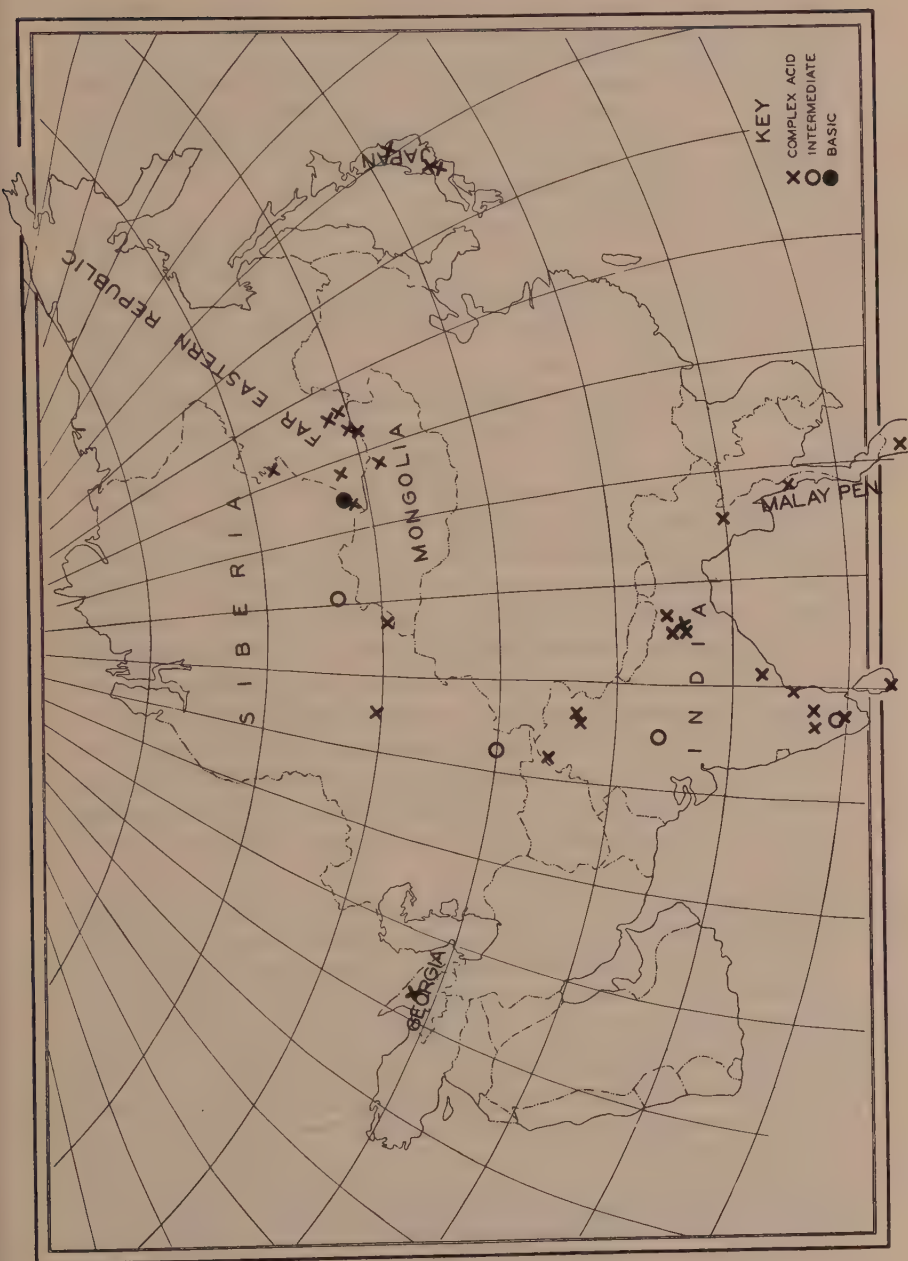


PLATE V. Distribution of complex acid, intermediate and basic pegmatites in Asia.

Dzirul Massif, between the headwaters of the Rion and Kura rivers, western Georgia.

REFERENCES: Ginzberg, A., To the petrography of Trans-Caucasia (Russian): *Mem. Radium Exped., Imp. Acad. Sci.*, no. 4, pp. 1-30, 1915. Abstract in *Mineral. Abstracts*, no. 2, p. 115. Kusnezova, E., Materials for the study of pegmatite veins of the Dzirul Massif, Transcaucasia: *Bull. United Geol. and Prospecting Service, U.S.S.R.*, L. Fascicle 98, pp. 1-19, 1931.

SIBERIA AND THE FAR EASTERN REPUBLIC. A wide belt of crystalline rocks crosses southern Siberia and the Far Eastern Republic from west to east. Pegmatites occur at a number of localities along this belt, especially in Transbaikalia. Granite pegmatites are most abundant. These have a prominent tin phase at several localities in the Borschevochni Range (adjacent to the Mongolian border in Transbaikalia). Lithium, tourmaline and quartz vein phases are also present in this district. A beryllium phase occurs in pegmatites of the Altai Range, near the western boundary of Mongolia, and in the Adun-Chalon Range of eastern Siberia. Granodiorite pegmatites in the Vitun River area, north of Lake Baikal, contain beryllium and ore mineral phases, beside large reserves of muscovite mica. A fluorine phase is present in pegmatites in Kazakstan (northeastern outskirt of the Kirghiz Steppe). A rare earth mineral phase occurs in granite pegmatites in Irkutsk province near the southern end of Lake Baikal. In the same district are basic pegmatites with an apatite-phlogopite phase. Rare earth minerals also occur in syenite and nephelite syenite pegmatites in the vicinity of Minussinsk on the upper Jenissei. Simple nephelite syenite pegmatites are found in the Alai Range of Turkistan.

REFERENCES: Artemiev, B., Materials to the knowledge of the tin deposits of east Transbaikalia: *U.S.S.R. Geol. and Prospecting Service, Bull.* 49 (7), pp. 29-45, 1930 (English summary pp. 44-45). Assovski, A. N., Some data on tin occurrences in the Borschevochni Range (east Transbaikalia): *U.S.S.R. Geol. and Prospecting Service, Bull.* 49 (7), pp. 17-27, 1930 (Russian, English summary pp. 26-27). Fersman, A. E., Les résultats minéralogiques d'une expédition en Daourie en 1915: *Compt. Rend. Acad. Sci. Russie*, pp. 65-68, 1923. Abstract in *Mineral. Abstracts*, no. 2, pp. 264-265. Holmov, George, Minerogenetic sketch of Duldurga tungsten deposit (Transbaikalia): *Trans. United Geol. and Prospecting Service of U.S.S.R.*, Fascicle 133, 1931, English summary pp. 35-36. Kassin, N. G., General geological map of the Kazakstan: *Trans. Geol. and Prospecting Service, U.S.S.R.*, Fascicle 110, pp. 1-260, 1931. Labasine, C., Sur les gisements de substances minérales radioactives dans l'arrondissement de Khakassk: *Trans. U.S.S.R. Geol. and Prospecting Service*, 19, pp. 1-56, 1930 (French summary pp. 55-56). Misharev, D. T., Mama-

Vitim-Chuisky deposits of mica: *Trans. United Geol. and Prospecting Service, U.S.S.R.*, Fascicle **154**, pp. 1-89, 1932, Moskvín, A. V., On the mikrokline from the river Joury-Say: *Travaux-de L'Institut Petrographique de l'Académie des Sciences de l'U.S.S.R.*, no. **3**, pp. 5-12, 1933. Wendland, C., microscopic study of pegmatites from the Mama mica district: *Trans. United Geol. and Prospecting Service, U.S.S.R.*, Fascicle **221**, pp. 1-34, 1932 (English summary pp. 33-34).

MONGOLIA. Complex granite pegmatites occur near Urga in northern Mongolia on the Gorikho river. Fluorine and beryllium phases are present.

REFERENCE: Kryjanowsky, V., Sur les pegmatites des environs d'Urga en Mongolie: *Compt. Rend. Acad. Sci. Russie*, pp. 13-16, **1925**. Abstract in *Mineral. Abstracts*, **3**, p. 439.

AFGHANISTAN. Muscovite pegmatites occur in southeastern Afghanistan.

INDIA. Pegmatites are abundant in the crystalline rocks of both peninsular and northern (Himalayan) India. The best known district lies in the provinces of Bihar and Orissa in Lower Bengal, northwest of Calcutta. Other important districts are northern India (especially Kashmir), east-central Rajputana, eastern Mysore, and the northern, central, and southern parts of Madras Presidency. Simple granite pegmatites predominate, but many complex granite pegmatites are present in the districts enumerated. A beryllium phase is developed at several localities in Lower Bengal, especially in the Kodarma district. Other pegmatites containing beryl occur near Nellore (north of Madras), at Bangalore (Mysore state), near Kishengarh in Rajputana, in the Coimbatore district of southern Madras, and in Chitral in northernmost India. A lithium phase is found in pegmatites in southern Kashmir and in the Hazaribagh district of Lower Bengal. Cassiterite accompanies the lithium minerals at Pihra, Lower Bengal. Granite pegmatites with a molybdenum phase occur in northern Madras near Kunaveram, in southern Madras west of Palni, and in the Kolar gold field of Mysore. Phosphate and rare earth mineral phases are developed near Kodarma and near Singar (Gaya district) in Lower Bengal. In addition rare earth minerals occur in the pegmatites of the Nellore (central Madras) and Bangalore (Mysore) districts. Syenite pegmatites with a corundum phase are found in the Coimbatore district of southern Madras and alkaline syenite pegmatites with a molybdenum phase occur near Kishengarh in Rajputana.



REFERENCES: Criper, W. R., The mica deposits of India: *Mem. Geol. Survey India*, vol. 34, pp. 131, 1902. Fox, C. S., Quinquennial review of the mineral production of India for the years 1924-1928: *Geol. Survey India*, vol. 64, 1930. Holland, Thomas H., The Sivamalai series of elaeolite-syenites and corundum syenites in the Coimbatore district Madras Presidency: *Mem. Geol. Survey India*, vol. 30, pt. 3, pp. 169-217, 1901. Mallet, F. R., On the occurrence of amblygonite in Kashmir: *Rec. Geol. Survey India*, vol. 32, pp. 228-229, 1905. Smith, Mervyn A., Mica mining in Bengal, India: *Mineral Industry*, vol. 7, p. 512, 1899. Tipper, G. H., Quinquennial review of the mineral production of India, 1914-18: *Rec. Geol. Survey India*, vol. 52, pp. 305-306, 1921. Wadia, D. N., *Geology of India, London, 1919*.

CEYLON. Simple granite pegmatites are common in the gneisses and associated crystalline rocks of Ceylon. Complex granite pegmatites with a rare earth mineral phase occur at Gampola and Hini-duma Pattu and a molybdenite phase is present near Kegalla.

REFERENCES: Adams, Frank D., The geology of Ceylon: *Can. Jour. of Research*, vol. 9, pp. 425-511, 1929. Rastall, R. H., Molybdenum ores: *Mono. Imp. Inst.*, pp. 1-86, 1920. Spencer, E., A contribution to the study of moonstone, etc.: *Mineral. Mag.*, vol. 22 (130), pp. 291-367, 1930.

BURMA. Pegmatites occur in Upper Burma in the crystalline rocks which lie north and northeast of Mandalay, especially in the Mogok district, and south of Mandalay in the vicinity of Yamethin. The Tavoy district of Lower Burma likewise contains pegmatites. Types: Granite simple and complex. Latter exhibit tungsten and beryllium phases at Yamethin and tungsten and tin phases at Tavoy.

REFERENCES: Brown, J. Coggin, Ruby mining in Upper Burma: *Mineral. Mag.*, vol. 48 (6), pp. 329-340, June, 1933. Campbell, J. Morrow, The ore minerals of Tavoy: *Mineral. Mag.*, vol. 20, pp. 76-89, 1919. Turner, H. W., Literature on the tungsten deposits of Burma: *Econ. Geology*, vol. 14, pp. 625-639, 1919.

MALAYA. Granite pegmatites are fairly common in the Malayan tin belt, especially in the Kinta Valley. Tin and tungsten phases predominate, but lithium, sulphide ore mineral, and fluorine phases are also present.

REFERENCES: Scrivenor, J. B., *The geology of the Malayan ore deposits, London, 1928*. Willbourn, E. S., and Ingham, F. T., Scheelite at Kramat Pulai (Malaya): *Mineral. Mag.*, vol. 48 (1), pp. 60-61, 1933.

CHINA. Simple granite pegmatites are found in a number of widely scattered localities in China. They have been reported as occurring in southern Manchuria, in the coastal provinces of Chekiang and Kwangtun, and in several interior provinces, especially Szechwan where muscovite mica has been mined.

REFERENCES: Ho, T. L., The anorthoclase perthite from Chu-Chiatsien island near Putochan, Chekiang: *Contrib. Nat. Research Inst. Geol. Acad. Sinica*, no. 4, pp. 31-40, 1933. Ogura, Tsutomu, Some dyke rocks in South Manchuria: *Mem. Ryojun College of Eng. (Manchuria)*, vol. VI, no. 9, pp. 155-174, 1933. Sen-Shing, Yoh, and Wen-Kwang, Yao: Preliminary report on the geology and mineral resources of Han Chiang region, eastern Kwangtung: *Geol. Survey Kwangtung and Kwangsi, Ann. Rept.* 4, no. 1, pp. 19-28, 1931-32. Tien-Chen, Lee, and Chen-Ping, Wang: The geology of Ch'anghsing, Wuhsing, Wuk'ang, Teht'sing, and Yü-hang districts: (Abstract) *Geol. Survey Kwangtung and Kwangsi, Ann. Rept.* 3, no. 2, pp. 27-64, 1929-1930.

KOREA. The greater part of Korea is underlain by granite and gneiss in which simple granite pegmatites occur.

REFERENCE: Ichimura, T., Notes on the titaniferous magnetite deposits of Shô-Enpê-Tô, Chôsen (Korea): *Mem. of Faculty of Sci. and Agric., Taihoku Imp. Univ.*, vol. 3, no. 3 (Geol., no. 1), pp. 249-266, Dec., 1931.

JAPAN. Granite pegmatites occur at a number of localities on the island of Honshu. These are complex with rare earth mineral and beryllium phases at Ishikawa, Iwaki province, and near Naegi, Mino province. Pegmatites with a fluorine phase occur in Mino and Omo provinces.

REFERENCES: Iimori, Satoyasu, et al., A new radioactive mineral found in Japan: *Inst. Phys. and Chem. Res. Tokyo, Sci. Papers* 15 (285), pp. 83-88, 1931. Iimori, S., Yoshimura, J., and Hata, S., A new radioactive mineral found in Japan: *Chem. News. London*, vol. 142, pp. 209-211, 1931. Abstract in *Mineral. Abstracts*, 4 (11), p. 500. Kimura, K., and Miyake, Y., On enalite, a new variety of uranothorite, found in Naegi, Gifu prefecture: *Jour. Chem. Soc. Japan*, vol. 53, pp. 93-100, 1932. In Japanese. Abstract in *Am. Mineral.*, 1933, p. 223, and *Mineral. Abstracts*, 5, p. 293. Uemura, Taku, Analysis of beryl from Ishikawa, Iwaki Province: *Japan Jour. Chem.*, vol. 2, pp. 117-121, 1923-1925. Analyses of columbite, monazite, samarskite, and ishikawaite (a new mineral) of Ishikawa, Iwaki Province: *Japan Jour. Chem.*, vol. 2, pp. 13-20, 1923.

#### AUSTRALIA AND ADJACENT ISLANDS

EAST INDIES. Pre-Cambrian rocks form the backbone of several East Indian islands, especially New Guinea. Simple granite pegmatites are present within the crystalline rock areas. Amphibole pegmatites occur on Obi Island in the Molucca group.

REFERENCES: Brouwer, H. A., Bijdrage tot de geologie der Obieilanden: *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indie*, vol. 52 (for 1923), pp. 3-62, 1924. Abstract in *Mineral. Abstracts*, 3, 1, 37-38. Ijzermann, R., Outline of the geology and petrology of Surinam, Dutch Guiana: *La Haye*, 519 pp., 1931. Abstract in *Rev. Geol.* vol. 13, no. 1391, 1932-1933.

WESTERN AUSTRALIA. Crystalline rocks, in which occur both simple and complex granite pegmatites, cover all of Western Australia except the western coast. The principal complex pegmatite districts are Pilbara and Wodgina in the northern part of the territory, Murchison and Lake Moore in west-central Western Australia,

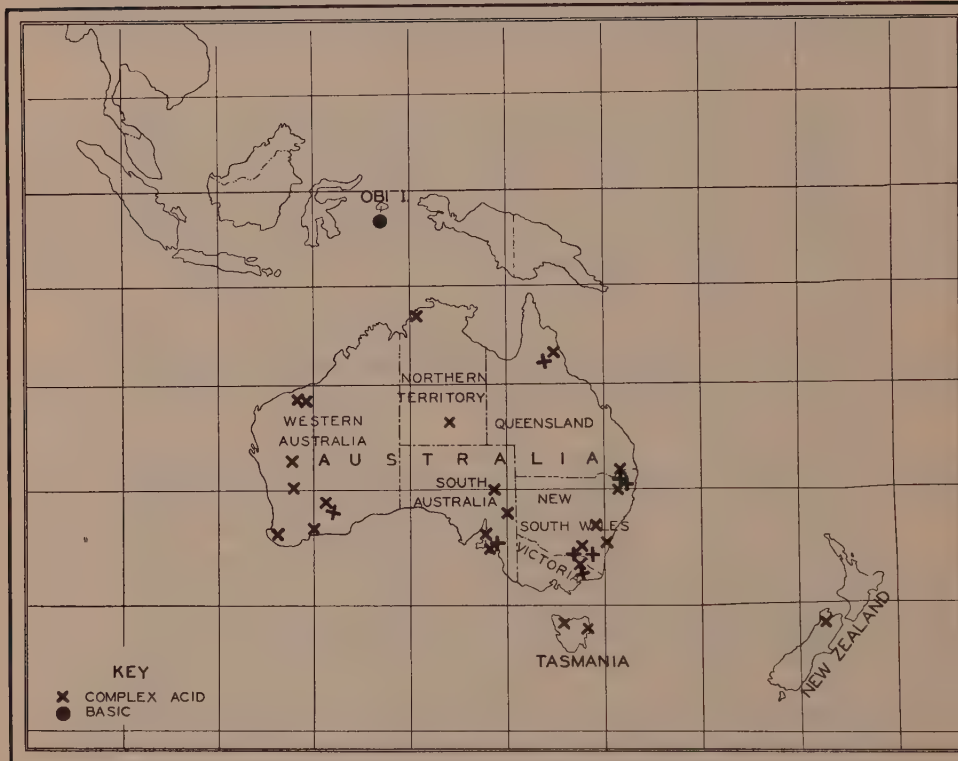


PLATE VI. Distribution of complex acidic and basic pegmatites in Australia.

and the Coolgardie, Dundas, Phillips River, and Greenbushes fields in the southern part of the territory. A rare earth phase is present in pegmatites at Cooglegong and Woodstock, Pilbara district, at Wodgina and vicinity (Green's Well and Mt. Francisco), and at Lake Moore. A lithium phase is found at Wodgina, Poonah (Murchison district), at Grosmont, Londonderry, and Ubini in the Coolgardie district, Norseman (Dundas district), at Ravens-thorpe and Coconarup in the Phillips River district, and at Green-



bushes. The pegmatites of the Wodgina district also contain a tin phase. A beryllium phase is present at Poonah, Ravensthorpe, and at Balingup, near Greenbushes. Basic pegmatites have been described (E. S. Simpson) at Nevoria (Central Division) and Bullsbrook (Southwestern Division).

REFERENCES: Blatchford, T., Mineral resources of the Northwest Division (Pilbara gold field): *Geol. Survey W. Australia*, Bull. 52, pp. 68, 69, 73, 1913. Blatchford, T., Geological investigations in the area embracing the Burbanks and London-derry mining centers: *Geol. Survey W. Australia*, Bull. 53, 1913. Farquharson, R. A., Petrographical notes on some specimens from Greenbushes: *Geol. Survey W. Australia*, Bull. 59, pp. 168-175, 1914. Maitland, A. G., Third report on the geological features and mineral resources of the Pilbara gold field: *Geol. Survey W. Australia*, Bull. 23, pp. 49, 1906 (reprinted Bull. 40, 1908). Simpson, E. S., Contributions to the mineralogy of Western Australia, Series VII: *Jour. Roy. Soc. W. Australia*, vol. 18, pp. 61-74, 1931-1932. Simpson, E. S., Contributions to the mineralogy of Western Australia, Series VI: *Jour. Roy. Soc. W. Australia*, vol. 17, 1930-1931. Simpson, E. S., The rare minerals and their distribution in Western Australia: *Geol. Survey W. Australia*, Bull. 59 (Miscel. Repts. 35), pp. 35-37, 1914. Simpson, E. S., Famous mineral localities: Wodgina, northwest Australia: *Am. Mineral.*, vol. 13, no. 9, pp. 457-468, 1928. Simpson, E. S., and Glanert, L., Description of the crystalline rocks of the Phillips river district: *Geol. Survey W. Australia*, Bull. 35, 47 pp., 1909.

NORTHERN TERRITORY. Complex granite pegmatites with a lithium (amblygonite) phase occur near Bynoe Harbour in the northwestern part of the territory. Simple granite pegmatites are abundant in the Hart and Macdonnell Ranges in southern Northern Territory. A beryllium phase is developed in pegmatites in the latter range.

SOUTH AUSTRALIA. Granite pegmatites occur in a belt which extends northward from the coast southeast of Adelaide to the northern extremity of Flinders Range. These are complex with a rare earth phase on Mount Painter (Flinders Range), Radium Hill (near Olary), and at Normanville, south of Adelaide. Ore mineral phases are present in the mining districts of Wallaroo and Moonta. Beryl is present in pegmatites in the Adelaide district at Williams-town and in the Olary district at Bimbowrie and Boolcoomata.

REFERENCE: Jack, R. L., The geology of Moonta and Wallaroo mining districts: *South Australia Geol. Survey*, Bull. 6, pp. 1-135, 1917.

QUEENSLAND. Pegmatites are most numerous in the crystalline rock belt of northern Queensland. They also occur in southeastern Queensland (adjacent to New South Wales) and in isolated crys-

talline rock outcrops in the northwestern portion of the territory. Types of pegmatite: Granite simple and complex. Latter have a molybdenum phase at Stanthorpe, southeastern Queensland, a tungsten phase at Bamford, and ore mineral and beryllium phases at Mount Carbine. Both Bamford and Mount Carbine lie in the gold fields of north Queensland.

REFERENCES: Ball, Lionel C., The wolframite, molybdenite, and bismuth mines of Bamford, N. Queensland: *Queensland Geol. Survey*, Pub. **248**, 1915, Rastall, R. H., Genesis of wolfram ores: *Geol. Mag.*, vol. **5**, pp. 193 et seq., 1918.

NEW SOUTH WALES. Granite pegmatites are fairly numerous within a 200 mile wide belt which borders on the Pacific Ocean. They are especially abundant in the New England district of northeastern New South Wales. Simple pegmatites also occur in the Broken Hill mining district of western New South Wales. Complex granite pegmatites with a beryllium phase occur near Elsnore, Deepwater (Torrington), Emmaville, and Tingha in the New England district, at Ophir in east-central New South Wales, and near Bungonia, Albury, and Kiandra in the southeastern part of the province. Ore mineral (especially tin, tungsten, molybdenum, and bismuth) phases are present in pegmatites at or near Elsnore, Torrington, Emmaville, and Guyra, all in the New England district. Lithium minerals have been found in New England at Black Swamp and in County Wynyard near Wagga Wagga.

REFERENCES: Andrews, E. C., The molybdenite industry in New South Wales: *New South Wales Mineral Resources*, no. **24**, 1916. Anderson, C., Mineralogical notes: *Rec. Australian Museum*, vol. **IV**, 1902. Card, G. W., Mineralogical and petrographical notes, No. 9: *Rec. Geol. Survey New South Wales*, vol. **8**, pp. 153-156, 1905. Carne, J. E., The tungsten-mining industry in New South Wales: *Dept. Mines New South Wales, Mineral Resources* no. **15**, pp. 58, 67, 71, 93, 1912. David, T. W. E., Geology of the Vegetable Creek tin-mining field, New England district, New South Wales: *Mem. Geol. Survey New South Wales*, no. 1, 1887. Cotton, L. A., The tin deposits of New England: *Proc. Linnean Soc. New South Wales*, vol. **34**, pp. 733-781, Nov. 24, 1909. Conder, Hartwell, The wolfram deposits of New England, New South Wales: *Min. Jour.*, vol. **78**, pp. 170-171, 1905. Liversidge, A.: *The minerals of New South Wales, etc.*, London, **1888**. Morrison, M., report on the Mt. Booralong molybdenite mine, near Guyra (County Hardinge): *Ann. Rept. Dept. Mines, New South Wales*, pp. 109, 111, **1920**.

VICTORIA. Tin-bearing pegmatites traverse metamorphosed sedimentary rocks in the Koetong, Cudgewa, and Glen Wills districts of northeastern Victoria. Pegmatites with a gold-quartz vein phase occur at Dargo and Omeo in eastern Victoria.

REFERENCES: Dunn, E. J., Tin ore at Glen Wills: *Records Geol. Survey Victoria*, vol. 2, pt. 2, pp. 104-105, 1907. Tolman, Carl, Quartz dikes: *Am. Mineral.*, vol. 16, no. 7, pp. 278-299, 1931.

TASMANIA. Pegmatites with a high temperature ore mineral phase occur in the Avoca district of eastern Tasmania and in the Forth River valley in the northwestern part of the island. Beryl is also present at the latter locality.

REFERENCES: Reid, A. McIntosh, The mining fields of Morina, Mt. Claude, and Lorinna: *Tasmania Geol. Survey*, Bull. 29, pp. 1-180, 1919. Reid, A. McIntosh, and Henderson, Q. J., Avoca mineral district: *Tasmania Geol. Survey*, Bull. 40, pp. 1-143, 1929.

NEW ZEALAND. Simple granite pegmatites occur along the west coast of South Island and on Great Barrier Island. A sulphide ore mineral phase is found in complex granite pegmatites of the Mount Radiant district on South Island.

REFERENCES: Bartrum, J. A., Notes on the geology of Great Barrier Island, New Zealand: *Trans. New Zealand Inst.*, vol. 53, pp. 115-127, 1921. Webb, E. J. H., The geology of Mt. Radiant Subdivision, Westport Division: *New Zealand Geol. Survey*, n. s., Bull. 11, pp. 1-46, 1910.

ANTARCTICA. Simple granite pegmatites have been noted on the mainland of South Victoria Land and on Scott's Nunataks in King Edward VII Land.

REFERENCES: Mawson, D., Petrology of rock collections from the mainland of South Victoria Land: *Brit. Antarctic Exped.*, 1907-9, *Rept. Sci. Invest., Geol.*, vol. 2, pp. 201-234, 1916. Schetelig, J., Report on rock specimens collected on Roald Amundsen's South Pole expedition: *Videnskapsselsk. Skrifter, I Mat.-Naturv.*, no. 4, pp. 1-32, 1915. Abstract in *Mineral. Abstracts*, 2, pp. 77-78.



## JAROSITE IN TUFF FROM POTOSI, BOLIVIA\*

CHARLES MILTON, *U. S. Geological Survey.*

### INTRODUCTION

In the course of a petrographic examination of South American specimens in the Johns Hopkins University collection the writer found a specimen of tuff, which on account of its origin and associations, as well as the presence of a notable percentage of jarosite, seems to warrant a brief description. The tuff came from a lake bed and contains many well preserved fossil leaves, which explains its collection, but only the associated minerals will be described here. Jarosite has been described from Potosi as occurring in a specimen of oxidized ore by Lindgren and Creveling.<sup>1</sup>

### OCCURRENCE AND FIELD RELATIONS.<sup>2</sup>

The tuff was collected by Berry and Singewald in 1919 on the George Huntington Williams Memorial Expedition on the west side of Potosi Mountain, Bolivia, which has an elevation of about 16,000 feet, rising 3,000 feet above the town of that name which lies at the foot of the north slope. The mountain is a rhyolite porphyry intrusion in steeply dipping early Paleozoic slates. On the west side of the mountain, near the Carrasco mine, is a saddle which separates the main mountain from a northerly sloping ridge called Huakachi. In this vicinity the Paleozoic slates are unconformably overlain by flatter-dipping plant-bearing stratified tuffs of Pliocene age. Collections from these tuffs were first described in 1887 by H. Englehardt. In 1915 Miller and Singewald made further collections which were described in 1917 by E. W. Berry; and in 1919 Berry and Singewald again collected specimens at this locality. It was in a tuff from their collection that the jarosite was found.

### PETROGRAPHY OF THE TUFF

The tuff is very fine-grained, siliceous, light in color, with slightly brownish fracture planes. The bedding is a prominent feature,

\* Published by permission of the Director, U. S. Geological Survey.

<sup>1</sup> Lindgren, Waldemar, and Creveling, J. G., The ores of Potosi, Bolivia: *Econ. Geol.*, vol. 23, p. 253, 1923.

<sup>2</sup> For the information contained in this paragraph, I am indebted to Dr. J. T. Singewald, Jr.

there being scores of well defined bedding planes to the inch of thickness. Microscopically, it is seen to consist of exceedingly comminuted lava, or volcanic glass, still partly isotropic. Extremely small angular particles of quartz, and a few equally small prismatic pale colored tourmalines, are also present. The fossil leaves show up under the microscope as patches of black opaque carbonaceous matter. Along the bedding planes brownish-yellow areas can be seen with the naked eye; these consist essentially of jarosite.

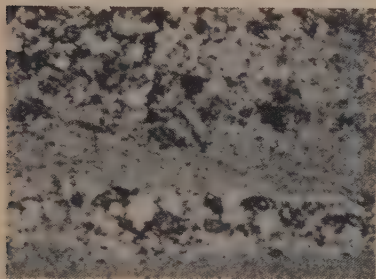


FIG. 1. Jarosite tuff showing stratification,  $\times 70$  ordinary light.

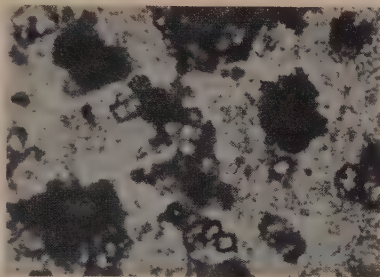


FIG. 2. Jarosite tuff showing jarosite rhombs and aggregates,  $\times 167$  ordinary light.

Microscopically, the jarosite is seen to be disseminated throughout the entire rock, even where none is visible to the eye. Besides being abundantly present in the coarser of the various bedding laminae, it is also concentrated in microscopic veinlets at right angles to the bedding. Where much jarosite is present there is also some quartz, some of it showing euhedral prismatic development. The relations seem to indicate essentially simultaneous formation of this quartz and the jarosite. The jarosite is golden yellow in color, not perceptibly pleochroic, and occurs in aggregates of poorly developed crystals and in single perfectly defined rhombohedra. Interference figures are secured with difficulty, owing to the minute size of the grains; they are uniaxial, negative. The crystals extinguish sharply parallel to the diagonals of the rhombs. A few grains become practically invisible when immersed in an oil of index 1.72; and all grains become so, at one extinction position, in an oil of index 1.82; hence  $\omega = 1.82$ ,  $\epsilon = 1.72$ , approximately. The smaller crystals appear to be homogeneous, with apparent twinning or intergrowths, but many of the larger crystals appear

to be hollow skeletal forms, the outer shell of jarosite enclosing what appears to be quartz, having the shape of a negative crystal of jarosite.

A sample of the tuff was prepared for analysis by crushing to 100 mesh, which gave the following results on treating with hydrochloric acid.

Soluble in HCl (jarosite)	14.49
Insoluble (dried at 110°C.)	84.20
Water (by difference)	1.31
	<hr/> 100.00

The soluble portion yielded the following constituents:

		RATIOS
Fe <sub>2</sub> O <sub>3</sub>	7.00	3.00
SO <sub>3</sub>	4.72	4.00
K <sub>2</sub> O	1.42	1.03
Na <sub>2</sub> O	0.16	
Al <sub>2</sub> O <sub>3</sub>	0.85	
TiO <sub>2</sub>	0.13	
SiO <sub>2</sub>	0.21	
CaO	Trace	
MgO	Trace	
P <sub>2</sub> O <sub>5</sub>	Trace	
CuS	None	
PbS	None	
	<hr/> 14.49	

A small quantity of tuffaceous material other than jarosite was dissolved by the acid, but the Fe<sub>2</sub>O<sub>3</sub>:SO<sub>3</sub>:K<sub>2</sub>O ratio agrees well with the 3:4:1 ratio of jarosite. It is assumed, for the purpose of calculation, that all the K<sub>2</sub>O is in the jarosite, and all the Na<sub>2</sub>O is in the tuff; this is probably not true, but such an assumption does not substantially affect the accuracy of the formula as calculated, or the conclusion that the rock contains some 16 per cent of jarosite.



## MEMORIAL OF HENRY STEPHENS WASHINGTON

J. VOLNEY LEWIS, *Washington, D.C.*

Henry S. Washington, distinguished leader in the chemistry, mineralogy, and petrology of the igneous rocks, and in 1924 President of the Mineralogical Society of America, died in Washington, D.C., on January 7, 1934, within eight days of his sixty-seventh birthday. He has been justly called one of the most eminent and picturesque personalities in American science.



HENRY STEPHENS WASHINGTON  
1867-1934

A descendant in collateral line from the family of George Washington, he was born in Newark, New Jersey, on January 15, 1867, the son of George and Eleanor Stephens Washington. Schooled in the classics at Yale University, where he received the degree of A.B. in 1886 and A.M. in 1888, he pursued graduate work in physics and chemistry at Yale, in geology and petrology at Leipzig, and in archeology at the American School of Classical Studies at Athens. He received the degree of Ph.D. at Leipzig in 1893, the subject of his inaugural dissertation being a study of the volcanoes of the Kula Basin in Lydia. During two of these earlier years he was assistant in physics at Yale.

During a part of each winter and spring for the six years, 1888–1894, Washington was engaged in archeological studies at Athens. He participated in a considerable number of excavations in various parts of Greece and made material contributions toward their expenses, and in some cases assumed the whole cost himself. Concerning one of these the Director of the school reported:

It was decided . . . to begin excavations at once, especially as Mr. Washington was ready to take charge of the work and generously provide the money.

In another annual report the Director refers to Washington as follows:

Owing to the experience which for several years past he has acquired in such work, as well as to his enthusiasm and unselfish devotion, his services were such that I can hardly realize how the undertaking could have been carried out as it has been done without his cooperation.

His knowledge of geology was of peculiar assistance in these excavations, but he quickly developed competence also in the more strictly archeologic technic. In all of these labors he achieved results of permanent value. These are set forth in a series of contributions to the *American Journal of Archeology* from 1890 to 1898. It is notable but not surprising to find that his investigation of the date of the Santorini vases showed a lively interest in volcanic activity; that he contributed a chapter on the geology of the region to the final report on the Argive Heraeum; and that he identified the sources of the marbles used in Greek sculpture. Archeology was in the ascendancy, but geology was firmly established.

Washington's return to Yale in 1895 as instructor in mineralogy marks the end of the "archeological period," but the subject held a lifelong place in his affections. It was a part of the equipment of a keen and amazingly versatile mind. In later years he found peculiar pleasure in the investigation of worked jade and obsidian artifacts from Mexico and Central America. Nevertheless, he had turned definitely now to that field in the earth sciences that claimed his devotion for nearly forty years of fruitful toil.

Teaching did not appeal to Washington as a life work. He was eager to give himself wholly to his research; so in 1896, being financially independent, he established a private laboratory at his home in New Jersey and began that intensive study of the igneous rocks and minerals which he pursued until the end. It was a program of endless toil and to a less zealous spirit much of it would

have seemed drudgery. Thoroughness and the utmost in accuracy were fundamental with him; the life of the dilettante offered no temptation. Even as a young man financial resources meant only the opportunity for thoroughgoing investigation in his chosen field. When reverses came he grudgingly gave part of his time to consulting work as a mining geologist, and in this connection he maintained an office in New York from 1906 to 1912. The writer's association with him during this trying period is a treasured memory. In 1912 he returned wholly to his research with the transfer of his labors to the Geophysical Laboratory of the Carnegie Institution of Washington, where he remained continuously, except for the war years 1918 and 1919, when he served as chemical associate and scientific attaché at the American Embassy in Rome.

In this place it is of peculiar interest to note that his first papers, as a young man just out of college, were contributions to mineralogy, with W. E. Hidden in 1887 and with W. F. Hillebrand in 1888. This persistent thread of interest was again taken up in 1896, with direct contributions to mineralogy, and these continued in a long series through the years, many of the later papers having been prepared in collaboration with his colleagues at the Geophysical Laboratory. Early petrographic papers also followed the lines of abiding interest. They were concerned with the study of rock analyses, petrographic provinces, and the genetic classification of igneous rocks.

In the chemical relations of the igneous rocks and in their broader petrologic aspects Washington was an outstanding authority. In the advocacy of thoroughness in this field he became also a leader in the demand for higher standards of accuracy and completeness in chemical analyses. His *Manual of the Chemical Analysis of Rocks* (1st ed. 1904, 4th ed. 1930) has been the standard textbook in its field for thirty years. Although written primarily for the unpracticed student, this book is known to chemists in the inorganic field everywhere, and it has contributed much in a constructive way toward raising the standard of precision in rock analysis.

Washington's surpassing interest in igneous rocks and his amazing capacity for painstaking toil are attested by his collections of the chemical analyses of rocks, with critical discussion of the character and use of analyses—all ranked according to quality calculated into "normative minerals," and classified according to the quantitative system developed by him in collaboration with

Dr. Whitman Cross, Professor J. P. Iddings, and Professor L. V. Pirsson. These collections, published in Professional Papers 14, 28, and 99 of the United States Geological Survey, are also landmarks in the transformation of descriptive petrography into the science of petrology. Professional Paper 99 is a quarto volume of 1201 pages. "It is known to every geologist in the world. To those of Washington's acquaintances unfamiliar with the more earnest side of his character the amount of patient investigation and even drudgery to which he was willing to devote himself in this work is almost unbelievable."<sup>1</sup>

The Quantitative Classification of Igneous Rocks may not have solved that difficult problem in its entirety, but it stimulated the interest of petrographers and geologists everywhere in the chemical and mineral constitution of these rocks and in the effort to devise a practical scientific method of classification. This interest has been reflected in part in the several alternative systems that have been proposed. Complacent acquiescence in the old condition of chaos in this field has been definitely brought to an end.

Research in the igneous rocks led naturally in the later years to their broader connotations in the distribution and correlation of the chemical elements in these rocks and in the radial distribution of these elements in the earth. In a similar manner the horizon broadened from the earlier conception of petrographic provinces into comagmatic regions, the rock suites of the Pacific and Atlantic basins, and the constitution of the earth, meteorites, and the sun's atmosphere.

Washington's extensive bibliography is dominantly petrographic and petrologic, rather than mineralogic; nevertheless it contains many papers on mineralogical subjects, in which his interest was chiefly in their chemical rather than their optical or crystallographic properties.

As a member of the committee on nomenclature of the Mineralogical Society of America he contributed much to the accuracy and usefulness of its recommendations, and from his extensive knowledge of languages pointed out the correct etymology and consequent proper pronunciation of many of the mineral names.

His presidential address before the Mineralogical Society at the Ithaca meeting dealt with the modern study of minerals. He combated the idea that mineralogy is a "fertiges Wissenschaft"

<sup>1</sup> Fenner, C. N. *Science*; n.s., vol. 79, p. 47, Jan. 19, 1934.



and emphasized the broader conception in which a knowledge of the constitution of minerals is sought and of how they are formed, their relations to each other, to their conditions of formation, and to the earth. In furtherance of these aims he urged careful accurate work, preferably by specialists in each field, on identical homogeneous material, so that all crystallographic, optical, chemical, physical, and *x*-ray data may be accurately correlated.

The thoroughness and permanent value of his work have been recognized throughout the scientific world, and this recognition has been reflected in the official positions and the honorary memberships to which he has been elected in many countries. He was a member of the National Academy of Sciences; the Geological Society of America (vice-president 1922); the Mineralogical Society of America (president 1924); the American Chemical Society; American Philosophical Society; Archeological Institute of America; American Geophysical Union (chairman 1926-1929); International Geophysical Union (vice-president 1922); Washington Academy of Sciences; Geological Society of Washington. He was decorated Cavalier of the Order of the Crown of Italy; elected foreign correspondent, Geological Society of London; honorary member, Mineralogical Society (England); Academie Sci. de France; foreign correspondent, Sociedad Española de Historia Natural; foreign member, Accademia dei Lincei; Societa Geologica Italiana; Societa Zelanti (Aci Reale, Sicily); Academy of Science Norway; Academy of Science Modena; Academy of Science Turin.

In the course of his investigations Washington traveled widely in Greece, Asia Minor, Italy, Spain, Brazil, the Hawaiian Islands, and the United States. He possessed an amazing facility in languages, which he acquired with little apparent effort wherever he went. Thus to his knowledge of classical Greek and Latin he readily added German, French, Italian, Spanish, Portuguese, modern Greek, and even Arabic and Turkish.

Washington's magnetic personality was enriched by his brilliant intellect, his broad culture, and his genuine interest in and knowledge of an astonishing range of topics, not only in the physical and natural sciences, but in literature, history, music, art, archeology, ethnology and philology. Following the intense seriousness of his research and his writing he found relaxation in the lighter mood, and his lively wit and keen sense of humor were a constant source of delight to those who had the privilege of knowing him.

"Washington took much delight in associating with congenial friends and was one of the most active members of the Cosmos Club of Washington. In more public assemblages his features and bearing were of a character to make him an outstanding figure. His was a many-sided and exceptional personality, in many ways almost unique. His contributions to science are of lasting value."<sup>2</sup>

<sup>2</sup> Fenner, C. N., *loc. cit.*, p. 48.

### MEMORIAL OF STEPHEN RICHARZ

VICTOR T. ALLEN, *St. Louis University*.

Reverend Stephen Richarz, S.V.D., was born at Richrath, Germany, on November 25, 1874. He joined the Society of the Divine Word in 1893 and entered the seminary of Missionhaus St. Michael, Steyl, Holland. His philosophical and theological



STEPHEN RICHARZ  
1874-1934

studies were carried on at Missionhaus St. Gabriel, Moedling, near Vienna, Austria, and here he was ordained a Catholic priest in 1901. The period, 1905-1917, was devoted to private study and to the teaching of science at St. Gabriel. His interest in geology was inspired by his professors at St. Gabriel, the University of Vienna (1903-04), and the University of Munich (1904-05; 1917-1919),

and by visits to the eastern Alps, the Carpathian Mountains of Hungary, the Tertiary Basin of Vienna and Oberpfalz, Bavaria. In 1919 he received the degree of doctor of philosophy in geology, mineralogy, and geography at the University of Munich. The title of his doctoral dissertation was: "Die Basalte von Groschlattengruen in der Oberpfalz mit besonderer Berücksichtigung ihrer Einschlüsse und Neubildungen." For several years he was professor of geology and astronomy at St. Gabriel's and at St. Rupert's and he served a term as rector of St. Gabriel's from 1914-17.

In 1921 the Reverend Doctor Richarz came to the United States and joined the faculty of St. Mary's College, Techny, Illinois, as professor of geology, astronomy, chemistry, and mathematics. Here he remained, active in teaching and geological research until 1933 when he was appointed Dean of the College of Science at the Catholic University of Peking, China. His ardent enthusiasm for geological research led to his death in this new country within a year of his arrival. On July 17, 1934, he died while on an expedition to investigate geological discoveries in Ming Yin, South Shantung. The Reverend Father Wehner, S.V.D., who was with him on the expedition, attributes Father Richarz's death to drinking cold water while exhausted from a long journey during sweltering heat. To his last he was devoted to the science of his choice, and yet his labors in that field were never at the expense of his religious duties and ideals. In his passing the Mineralogical Society loses an active fellow and a frequent contributor.

Father Richarz's broad interest in science is attested by the number of scientific organizations in which he retained membership and the wide scope of his scientific publications. He was a fellow of the Mineralogical Society of America, the Geological Society of America, and the American Association for the Advancement of Science, and a member of the Wiener Geologischen Gesellschaft, the Deutschen Geologischen Gesellschaft, and the Illinois State Academy of Science.

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3. Der südliche Teil der Kleinen Karpathen und die Hainburger Berge, *Jb. der. k.k. geol. Reichsanstalt Wien*, vol. **58**, pp. 1-48, 1908.
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## LINDGRENITE, A NEW MINERAL

CHARLES PALACHE, *Harvard University.*

### (Abstract)

Lindgrenite is a molybdate of copper,  $\text{Cu}_2\text{MoO}_4 \cdot \text{Cu}(\text{OH})_2$ . It is monoclinic, with the elements:  $a:b:c=0.5941:1:0.5124$ ,  $\beta=92^\circ 12'$ . The dominant forms on the crystals are: (010), (100), (121), and  $(\bar{1}31)$ . In addition to these, ten other forms were observed in varying degrees of development. The green crystals are tabular parallel to the clinopinacoid (010), which is also the direction of a perfect cleavage. It occurs in veinlets in limonitic quartz in the copper mine at Chuquicamata, Chile. It was found by M. C. Bandy and is named in honor of Dr. Waldemar Lindgren.

# PROCEEDINGS OF THE FIFTEENTH ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA AT ROCHESTER, NEW YORK

PAUL F. KERR, *Secretary*.

The fifteenth annual meeting of the Society was called to order Thursday, December 27th, at 2:00 P.M. in Room 206, Chester Dewey Building, University of Rochester, Temporary Chairman A. H. Phillips presiding. The customary business of the society was conducted, including reports by the officers of the society and committees summarized as follows:

MINUTES OF THE LAST ANNUAL MEETING. (Not called for because of previous publication in *The American Mineralogist*, vol. 19, pp. 122-136, 1934.)

DECLARATION OF VOTES FOR OFFICERS AND FELLOWS FOR 1935.

REPORT OF THE SECRETARY.

REPORT OF THE EDITOR.

REPORT OF THE TREASURER.

MEMORIALS:

A brief oral tribute was presented by Dean Edward H. Kraus of the University of Michigan for Henry S. Washington and Stephen Richarz.

Members and visitors rose and stood for a minute in silence out of respect to the memory of our departed fellows at the conclusion of Dean Kraus' address.

REPORTS OF COMMITTEES:

Auditing Committee: Read by Dr. Tom. F. W. Barth, Chairman.

Committee on Affiliation: Read by the Secretary.

Committee on Nomenclature: The Chairman, Dr. W. T. Schaller, requested that the committee be continued although no report was made for 1934.

The business meeting was adjourned at 2:45 P.M. and the President, John E. Wolff, took the chair to preside over the presentation of papers.

The report of the election of officers and fellows for 1935, the report of the Secretary, Editor and Treasurer and the report of the Auditing Committee are given in the following pages. The report of the Committee on Affiliation was printed in full in vol. 20, January, 1935.

## ELECTION OF OFFICERS AND FELLOWS FOR 1935

The Secretary announced that 174 ballots had been cast unanimously for the officers as nominated by the council. Officers were declared elected as follows:

*President*: Clarence S. Ross, U. S. Geological Survey, Washington, D.C.

*Vice-President*: J. Ellis Thomson, University of Toronto, Toronto, Ontario, Canada.

*Treasurer*: Waldemar T. Schaller, U. S. Geological Survey, Washington, D.C.

*Secretary*: Paul F. Kerr, Columbia University, New York, N.Y.

*Editor:* Walter F. Hunt, University of Michigan, Ann Arbor, Michigan.

*Councilor, 1935-1938:* J. F. Schairer, Geophysical Laboratory, Washington, D.C.

The Secretary announced that 76 ballots of fellows had been cast unanimously for nominees for fellowship previously approved by the council. Newly elected fellows were as follows:

J. D. H. Donnay, Johns Hopkins University, Baltimore, Maryland.

Edwin B. Eckel, Ganada, Arizona.

George M. Hall, University of Tennessee, Knoxville, Tennessee.

Edwin T. Hodge, University of Oregon, Eugene, Oregon.

Arthur Holmes, Science Laboratory, Durham, England.

James H. C. Martens, Morgantown, West Virginia.

James F. Morton, Paterson Museum, Paterson, New Jersey.

Thomas B. Nolan, U. S. Geological Survey, Washington, D.C.

Hugh S. Spence, Mines Branch, Ottawa, Canada.

C. E. Tilley, University of Cambridge, Cambridge, England.

#### REPORT OF THE SECRETARY FOR 1934

*To the Council and Members of the Mineralogical Society of America:*

The Secretary reports the statistics concerning the membership roll of the Society for the last twelve months as follows:

##### MEMBERSHIP STATISTICS

	December 1933	December 1934
Honorary fellows	5	4
Fellows	115	125
Members	280	291
Subscribers	257	268
	—	—
	657	688

##### GAIN AND LOSS FOR 1934

	Gain	Loss
Honorary fellows		1
Fellows (not including members elected fellows)		2
Members	60	46
Subscribers	28	8
	—	—
	88	57

It is interesting to note that the Society has made a net gain in membership of 31 or almost 5 per cent on the basis of the 1933 total. It should be recorded, however, that although both members and subscribers have shown an increase over the previous year the increase in subscribers has been proportionately greater than the increase in members. This appears to be due to the increasing desire on the part of scientific organizations, libraries, and research establishments to make use of *The American Mineralogist*.

A total of about 690 paid copies of *The American Mineralogist* is mailed monthly. These are distributed not only throughout the United States and Canada but a constantly increasing number of copies go abroad.

It is felt by the Secretary that the gain recorded above is in a large measure to be credited to the good will established over a number of years by the Editor, Treasurer and the previous Secretary of the Society. In conclusion it is proper to record appreciation of the efforts of Professor Albert B. Peck who took over the records of the Society during 1933 and turned them over in such excellent condition at the close of the year.

Respectfully submitted,  
PAUL F. KERR, *Secretary*

#### REPORT OF THE EDITOR FOR 1934

*To the Council, Fellows and Members of The Mineralogical Society of America:*

In the report of a year ago the statement was made that in so far as conditions at that time could be foreseen it did not seem likely that any expansion of *The American Mineralogist* was in sight, due to our practically stationary income on the one hand and the possibility of increased printing costs on the other. However, in summarizing the accomplishments of the Journal for the year 1934 it is gratifying to note that considerable progress can be reported along various lines.

In the first place the character of the Journal has been greatly improved through the use of a superior grade of coated paper thus permitting clearer detail in the illustrations, a feature of considerable importance especially in the reproduction of diffraction patterns and photomicrographs. Also, there has been about a 10 per cent increase in the size of the magazine compared with the volume of a year ago. In other words, the current volume exceeds slightly the 600 page mark, and in this respect a new record is established.

This expansion and improvements in the Society's publication were due in no small measure to the assurance of some financial assistance which was very generously voted by the Council of the Geological Society of America at a meeting held last April. Due, however, to certain formalities that had to be complied with and new procedures inaugurated the money was not immediately available so that the expansion, of necessity, had to be modest and restricted to the late issues of the year. Also, because of this aid a more liberal attitude than otherwise would have been possible, was followed in the number of permissible illustrations accompanying many of the manuscripts.

Volume 19 is represented by 58 leading articles received from 35 universities, research bureaus and technical laboratories. If to this number is added the 25 equally interesting but somewhat shorter contributions, we have a total of 83 published manuscripts received from no less than 76 contributors. It is always of interest to note whether articles are received from outside of the States. For many years we have been thus favored by one or more foreign contributions, and in 1934 this number was increased to seven—three from Canada, two from Holland and one each from Germany and South Africa.

On a number of occasions anxiety has been expressed in some quarters that papers dealing with petrography might not be given adequate attention due to the rapid expansion in other fields covered by our periodical. To those who hold this fear attention is called to the fact that during the year eight strictly petrographic



manuscripts have been published and it is our intention in the future to accept a larger number of such papers of moderate lengths should they become available.

As in previous years a survey of the titles of papers that have appeared in volume 19 will reveal the usual wide range of subject matter, including articles on descriptive, chemical and optical mineralogy; geometrical and structural crystallography; mineralography; petrography; as well as memorials to our distinguished deceased fellows. Also book reviews, abstracts of new mineral names, and numerous reports from mineralogical societies at home and in Great Britain have added many additional items of general interest.

The prospects for next year are exceedingly promising. It is our confident hope that the assistance received from the Geological Society of America this past year will be continued during 1935. This will permit of considerable further expansion and at the same time improve the service to contributors by reducing annoying delays in the printing of manuscripts after they have been accepted. In addition it will be possible to undertake shortly a project of major importance to all scientists who use *The American Mineralogist* as a work of handy reference. The year 1935 will conclude the twentieth volume of the Journal and it would seem very timely to consider seriously the issuance in one pamphlet of a carefully prepared bibliography and subject index covering this twenty-year period. Details have not yet been worked out but the cost has been roughly estimated at about \$1200. Perhaps through savings spread over a number of years a fund might be set aside to insure the success of this extremely desirable project.

The concluding table of contents summarizes the distribution of subject matter in volume 19.

## DISTRIBUTION OF SUBJECT MATTER IN VOLUME 19.

<i>Subjects</i>	<i>Articles</i>	<i>Pages</i>	<i>Per Cent of Total</i>
Leading articles			
Descriptive mineralogy	10		
Chemical mineralogy	9		
Optical mineralogy	7		
Structural crystallography and mineralography	8		
Geometrical crystallography	6		
Petrography	8		
Memorials, etc.	10		
	58	486	79.9
Proceedings of societies	32	39	
Short articles; notes and news	40	68	
Abstracts of new mineral names	19	7½	
Book reviews	9	7½	
			20.1
Total of text	158	608	100.0
Illustrations	156		
Covers, advertisements, index		114	
		722	
Total			

Respectfully submitted,  
WALTER F. HUNT, *Editor*.

## REPORT OF THE TREASURER FOR 1934

*To the Council of the Mineralogical Society of America:* Your Treasurer submits herewith his annual report for the year beginning December 1, 1933, and ending November 30, 1934.

## RECEIPTS

Cash on hand December 1, 1933.....	\$1,653.63
Dues and subscriptions.....	\$1,803.63
Advertisements.....	479.64
Sale of back numbers.....	80.64
Interest on endowment.....	\$2,352.75
Author's charges.....	36.54
Author's charges on separates.....	362.98
	<hr/>
	\$6,769.85

## DISBURSEMENTS

Printing and distribution of the Journal (12 issues)....	\$3,286.44
Printing and distribution of separates.....	543.89
To the Editor, Secretary and Treasurer.....	720.00
Postage.....	49.42
Stationery.....	2.85
Printing.....	52.36
Clerical help.....	127.44
Committee expenses.....	35.03
Safety deposit box.....	8.25
Bank collecting charges.....	1.51
Check tax.....	1.06
Refunds on dues.....	2.75
Checks returned.....	9.23
Telegram.....	0.86
Roebbling Medal Fund.....	100.00
	<hr/>
	\$4,941.09
Cash balance November 30, 1934.....	\$1,828.76
	<hr/>

\$6,769.85

The endowment funds of the Society as of November 30, 1934, are the same as a year ago, and consist of:

45 \$1,000 bonds of the City and County of Honolulu, Water Works, 5%, due 1954.....	\$45,000.00
4 Liberty bonds, \$100 each, 4th, 4¼%, due 1933-1938.....	400.00
4 \$100 bonds, Great Northern R. R., 5½%, due 1952.....	400.00
2 \$1,000 bonds, Trenton Mort. and Title Guar. Co., 5½%, due 1937.....	\$ 2,000.00
2 \$1,000 bonds, Trenton Mort. and Title Guar. Co., 5½%, due 1938.....	\$ 2,000.00

1 \$1,000 bond, Denver Gas and Electric Light Co., 5%, due 1951 . . \$1,000.00

\$50,800.00

In addition there is \$200.00 cash laid aside for the Roebling Medal Fund.

Respectfully submitted,

W. T. SCHALLER, *Treasurer*.

Washington, D.C.

December 14, 1934.

*To the President of the Mineralogical Society of America:*

The Auditing Committee has examined and verified the accounts and report of the Treasurer for the fiscal year ending November 30, 1934. The Committee also certifies that \$200.00 cash is laid aside for the Roebling Medal Fund. The securities listed in the Treasurer's report are in the safety deposit box in the vaults of the American Security and Trust Company of Washington, D.C. All future coupons are intact and are attached to these securities with the following exceptions: Four bonds of the Trenton Mortgage and Title Guaranty Company of a total par value of \$4,000, have been changed to registered bonds (registered both for principal and interest) and the coupons detached and destroyed.

TOM. F. W. BARTH, *Chairman*

HERBERT INSLEY

GEO. STEIGER

#### PRESIDENTIAL ADDRESS

The address of Dr. John E. Wolff, retiring President of the Mineralogical Society of America, was delivered on Thursday, December 27 at 12:30 P.M. in the Henry Strong Auditorium before the joint assembly of all societies.

#### CRAZY MOUNTAINS OF MONTANA—SUPER-ALKALINE AND SUB-ALKALINE TERTIARY INTRUSIVE ROCKS AND THEIR PROBLEMS

BY JOHN E. WOLFF, *Pasadena, California*

(Abstract)

The paper begins with a brief topographic and geological description of the range, which lies some thirty miles east of the Frontal range and is bounded on the south by the Yellowstone river, on the north by the Musselshell, on the west by Shield's river, and on the east by the tributaries of the Yellowstone and Musselshell, respectively. The area is forty-five miles long from north to south and twenty-five miles wide, divided by Shield's river into a southern area of high and rugged peaks (over eleven thousand feet above tide) with deep canyons, and several small residual glaciers, and a lower northern area, flat-topped and less dissected.

The range contains a remarkable assemblage of intrusive igneous rocks, including in the southern half, a large diorite stock with a mile wide contact ring, forming in ground plan an elongated oval six and a half miles long north and south by four miles east and west—twenty-two square miles in area, with many dikes cutting the mass, and small laccoliths, sills, and thousands of dikes in the enclosing Fort Union (Eocene) sediments. Canyons have cut down over three thousand feet into

the stock affording ideal exposures and fresh specimens. None of the super-alkaline rocks occur in this southern area, except at the extreme western foot of the mountains, six miles distant from the stock.

In the northern area the super-alkaline rocks occur in profusion in laccoliths, thick and thin sills and dikes, and in three volcanic necks. No effusive rocks, however, occur anywhere in the range. The Fort Union sediments have been here intensely folded, the folds running north and south and the intrusive sills dip with them. One stock of laurdalite is exposed near the north end, a quarter square mile in area, with an associated complex of allied rocks. In the middle of this northern area rises a smaller dioritic stock, four square miles in area, analogous to the larger one in the south but not so well exposed. Here again the alkaline rocks show no direct connection by contacts or apophyses, and the relative age of the two series cannot thus be determined.

In the southern area of high peaks, formed by the stock and its satellites, the Fort Union beds dip gently north into the range at its termination north of the Yellowstone River, and dip inward on the east and west sides, thus forming a broad flat syncline. The axis of the structure trends north, with some gentle parallel folds, but the strata arch into a dome on approaching the stock, to dip away in all directions. The strata are tilted, crushed, and injected by the diorite at the contact. At the north end of the area the diorite plunges at a low angle beneath the overlying sediments, which soon become nearly horizontal. There has been east-west compression in this area, but it was gentle compared to that in the northern area.

At least twenty different types of igneous rocks may be identified including the following common varieties:

#### *Alkaline*

Theralite (basic shonkinites). This is the original rock on which Rosenbusch established his theralite family of plutonic rocks. It contains about twelve different minerals of unusual freshness and is hence excellent for beginners to study.

Granite-porphry  
Laurvikite  
Nephelite syenite  
Soelvsbergite  
Alkali-syenites  
Bostonite  
Syenite-porphry  
Syenite aplite  
Alkali camptonite

#### *Lime-alkali*

Diorite  
Granite  
Aplite  
Essexite  
Gabbro  
Peridotite  
Diorite-porphry  
Augite porphry  
Biotite malchite  
Intermediate camptonites  
Diabase (and other porphyries)

On the basis of some thirty chemical analyses fifteen subranges of the C.I.P.W. classification are recognized in the double series. The silica ranges from 74% in the aplites to 40% in the peridotites. All the rocks show unusual amounts of BaO and SrO, reaching a maximum in the theralites of 0.76% BaO, 0.37% SrO, or 1.13% of the combined oxides. Na<sub>2</sub>O varies from 8.55% in nephelite syenite to 1.58% in picrite, and K<sub>2</sub>O from 6% in aplites to 0.85 in picrite. Soda is greater than potash in the entire series, and lime greater than magnesia, except in picrite.



Some mineral differences may be noted. Biotite is common in both series and is normal in the sub-alkaline rocks, but in the theralite it has 6° extinction angle to the cleavage, and 2V is about 17°. Barium is present spectroscopically.

The augites of the sub-alkaline types are diopside or pigeonite; in the alkaline, diopside in the center of crystals, becoming aegirite-augite and then aegirite at the periphery.

The hornblendes of the diorite series are pale green in the acid types to brown in the basic. In the alkaline series they are light green to yellow in acid rocks, and brownish-green in camptonites. One laccolith of theralite, rich in olivine, has a magnesian hastingsite, associated with the pyroxene.

The nephelite shows barium with the spectroscope.

The feldspars of the diorite series are normal orthoclase, micro-perthites in the aplites, and normal plagioclases, but in the nephelite syenites the anorthoclase phenocrysts have 1.13% of BaO+SrO, with both CaO and alkalies. In the theralite the orthoclase is a four component mineral (Ab 15, An 10, Or 67, Hyalophane 8). Sp. Gr. 2.59-2.61.

The lantern slides which illustrated this paper showed the magnificent exposures of the theralite, reaching a thickness of five hundred feet in Gordon's Butte and elsewhere, and will be reproduced in the completed monograph. Only a sketchy statement was made as to the possible origin and emplacement of these various rock masses, such as: that differentiation had occurred at depths, and in the emplacement different partial magmas were squeezed by orographic pressure into the places now occupied. A syenite magma was probably the immediate parent of the alkaline rocks: the reasons for these two suppositions are the facts that complementary dikes or sills are often found closely associated, and that in a neck of theralite, are blocks of alkali-syenite and alkali-granite brought up from depths, so that evidently there is here a large buried mass of syenite.

Pegmatites are wanting in the two series and pneumatolytic minerals such as tourmaline and other similar minerals are not present, so that the magma was "dry."

## PRESENTATION OF PAPERS

*Thursday Afternoon, December 27th*

At 2:40 P.M. the Society proceeded to the reading of scientific papers, President John E. Wolff presiding. Papers presented Thursday afternoon, included 23 titles devoted to general mineralogy and related subjects. Abstracts of these papers are given below:

AMBER FROM MANITOBA, by T. L. Walker.

The chemical and optical characteristics of chemawinitite, an amber from Cedar Lake, Manitoba. The insect fauna are described as revealed by an examination of part of the available material. The presence in the amber of a crystalline mineral, probably a hydrocarbon, for which, as a new mineral, the name *enelectrite* is proposed.

FURTHER STUDIES IN THE PYROXENE GROUP, by A. N. Winchell.

New data permit the presentation of new graphs showing the relations between variations in composition and in optical properties in the enstenite-diopside-hedenbergite system. Are end-members of variations properly called minerals?

## TOPAZ FROM DEVIL'S HEAD, by M. A. Peacock.

With field notes by Arthur Montgomery and Edwin Over, Jr.

Renewed operation in the pegmatites of Devil's Head, in the Pike's Peak region, have yielded a suite of noteworthy crystals of topaz associated with quartz, microcline, albite, fluorite and cassiterite. The collection includes some topaz crystals of outstanding size and regular development and many smaller crystals of unusually distorted habits. The forms observed are:  $c(001)$ ,  $b(010)$ ,  $g(130)$ ,  $l(120)$ ,  $m(110)$ ,  $X(023)$ ,  $f(011)$ ,  $y(021)$ ,  $h(103)$ ,  $d(101)$ ,  $i(113)$ ,  $u(112)$ ,  $o(111)$ , and  $r(121)$ , on the preferred parameters of Kokscharov. One crystal shows alteration to a mineral of the kaolin group, and they all exhibit corrosion effects, some of which are suitable for geometrical description.

## MORINITE FROM BLACK HILLS PEGMATITE, by J. J. Runner.

Preliminary examination of the physical, optical and chemical properties of a mineral from a pegmatite near Keystone, South Dakota, indicates that it probably belongs to the rare species morinite. The morinite occurs in veinlets replacing manganapatite and an unidentified mineral. These three minerals have apparently replaced amblygonite. A few small prismatic crystals of the morinite were obtained from cavities in the rock. The manganapatite and the amblygonite possess some unusual and interesting properties. Further studies of the properties of the morinite are being made which, it is hoped, will supply more complete data than are now available.

## PYROXMANGITE FROM IDAHO, by E. P. Henderson and Jewell J. Glass.

This study of the second occurrence of pyroxmangite, from Homedale, Idaho, confirms the composition of the original material from South Carolina and adds new and more complete optical data. The relationship between high iron rhodonites, pyroxmangite and sobralite is discussed and x-ray diffraction patterns of the rhodonites and pyroxmangite are compared.

## MINERALOGY OF SILICOSIS, by R. J. Colony.

Optical and x-ray study of the lung-ash of casualties from silicosis. An attempt to determine the presence of quartz, feldspar and other minerals in the ash of portions of the lungs of men exposed to rock-dust for a period of years, who have died as a consequence of such exposure, and whose clinical history is known.

## SILICA FRAMEWORK CRYSTALS AND THEIR STABILITY FIELDS, by M. J. Buerger.

The stable, high temperature forms of silica, tridymite and cristobalite, differ from the stable, low temperature form, quartz, principally by being open structures. Their open character is dynamically maintained by thermal agitations. It may also be statically maintained by inclusion of foreign ions, which therefore prevent re-packing at low temperatures to quartz structure. The foreign ion in question may enter the structure to balance the valence change brought about by substitution for  $Si^{4+}$ , some ion of lesser valence. If this substitution maintains the simple multiple proportions of the atoms, pure compounds are formed. The number of major polymorphous forms of the resulting compound is equal to  $n+1$ , where  $n$  is the number of remaining void spaces in the high-cristobalite-like phase of the compound. Thus,  $SiO_2$  has three,  $NaAlSiO_4$  has two, and  $Na_2CaSiO_4$  has only one major modification.

If the substitution does not maintain simple multiple proportions of all the atoms, the result is a solid solution rather than an ideal compound. This crystal cannot possibly have a quartz-like phase unless the valence balancing ion is hydrogen. This corresponds with chalcedony. Even if the valence balancing ions are present in amounts less than enough to fill half the void spaces, a tridymite structure may not be formed if these ions are not distributed in regular alternations. The natural tridymite and cristobalite minerals are therefore not necessarily metastable phases formed under permission of Ostwald's rule, but may be or may have been stable, impure silica. Levin and Ott's as well as Grieg's uninverted high-cristobalite at room temperature may also be impure silica.

**XONOTLITE FROM FRANKLIN FURNACE, by L. H. Bauer, and H. Berman.**

Xonotlite is found together with clinohedrite in a narrow vein cutting the ore, at Franklin, New Jersey. Optical determinations and an analysis establish the identity of the new occurrence of this rare mineral. The new find is noteworthy in that the crystals, although not terminated, are suitable for an x-ray crystallographic study. Preliminary examination shows that the crystals are monoclinic, and that the proper formula is  $\text{Ca}_3\text{Si}_3\text{O}(\text{OH}_2)$ .

**LINEAR MINERALOGICAL ARITHMETIC, by A. L. Parsons.**

A demonstration of the suitability of graphical methods for mineralogical problems involving chemical analyses where speed and accuracy are required.

**PRELIMINARY NOTE ON A SERIES OF SYNTHETIC FLUOR-AMPHIBOLES, by N. L. Bowen.**

During a study of the inversion of Mg, Fe'' pyroxenes in sealed tubes in the neighborhood of  $1000^\circ\text{C}$ ., it was necessary to resort to the use of a trace of NaF as a "catalyst" in some instances. A drusy coating of minute needle crystals of another phase formed on the pyroxene in these examples. These crystals have the properties of amphibole and are necessarily fluor-amphibole since no water was present. A pure magnesian end-member and a pure ferrous end-member were then prepared, as well as four of intermediate compositions. Members of the series are compared with their natural hydroxy-relatives in the cummingtonite-grünerite series. The extinction angles are slightly higher and the refractive indices notably lower than in corresponding members of the natural series. The lowering of refractive index is about the same as that produced in topaz by an equal substitution of fluorine for hydroxyl.

**CHEMICAL FORMULA AND CRYSTAL SYSTEM OF ALLEGHANYITE, by Austin F. Rogers.**

The formula  $5\text{MnO} \cdot 2\text{SiO}_2$  was assigned to alleghanyite. Water and fluorine were overlooked in the original analysis; a new analysis proves that the formula is  $2\text{Mn}_2\text{SiO}_4 \cdot \text{Mn}(\text{OH},\text{F})_2$ .

In thin-sections alleghanyite very much resembles chondrodite. It is similar to chondrodite in section angles in its orthorhombic syngony in twinning, in optical orientation, and in its internal structure as shown by an x-ray powder-photograph.

These findings prove beyond any reasonable doubt that alleghanyite is the manganese analogue of chondrodite and is isomorphous with it.

ASBESTOS, BARITE, CORUNDUM, RUTILE, AND VERMICULITE IN PENNSYLVANIA, by R. W. Stone.

Barite, corundum, and rutile, formerly produced and marketed in Pennsylvania, are no longer obtainable in commercial quantity. So-called asbestos "quarries," reported half a century ago, prove to be mere prospects on rare veins of cross-fiber chrysotile in serpentine. Vermiculite is known in two serpentine quarries. The occurrence of these minerals will be described.

HERDERITE FROM MAINE, by G. M. Yatskevitch.

Crystals of herderite— $\text{CaBe}(\text{OH},\text{F})\text{PO}_4$ —from Topsham, Maine, a new locality, exhibit several novelties: prismatic development in the direction of the  $c$ -axis, twinning on  $(\bar{1}00)$ , and the new forms  $\alpha(\bar{1}04)$ ,  $\beta^?(115)$ ,  $\gamma(121)$ . Herderite from a new find at Greenwood, Maine, shows the normal columnar development of the clinodome zone and known forms with the addition of  $\gamma(121)$ . The crystallography of the species is revised and referred to new parameters,  $a:b:c=0.6307:1:1.2822$ ;  $\beta=90^\circ 06'$ , obtained by trebling the  $c$ -axis of Penfield. The revised form list contains 33 accepted forms (2 new) and 11 uncertain forms (1 new). Three described forms are rejected. For the accepted forms a suitable angle-table is given.

$x$ -RAY STUDY OF ARSENIDES AND ANTIMONIDES OF NICKEL AND COBALT, by Ralph J. Holmes.

The  $x$ -ray powder method has been employed and standard patterns of the following minerals established by the method of multiple comparison: smaltite-chloanthite, safflorite, rammelsbergite, skutterudite, glaucodot, niccolite, breithauptite, cobaltite, gersdorffite, ullmannite and löllingite. Of these only smaltite and chloanthite yield identical  $x$ -ray diffraction patterns. The  $x$ -ray diffraction patterns of the other minerals in this group are distinctive.

Certain conclusions seem warranted by the data already assembled:

1. The orthorhombic diarsenides safflorite and rammelsbergite are of more widespread occurrence than has been generally recognized. This is illustrated by the results of the examination of material from several American localities. All specimens labeled "chloanthite" from Franklin, N.J., give patterns of the rammelsbergite type. "Chloanthite" (chathamite) from Chatham, Conn., is apparently safflorite. Examination of the ore from Cobalt, Ont., confirms Thomson's conclusion regarding the occurrence of safflorite and also indicates that both smaltite-chloanthite and skutterudite are common minerals at that locality.
2. Arite generally assumed to be an intermediate member of the niccolite-breithauptite series appears to be a mixture of niccolite and breithauptite.
3. Safflorite, rammelsbergite and löllingite, which have generally been assumed to be isomorphous yield diffraction patterns of a distinctly different type.

NEW OCCURRENCES OF PHENACITE, by Frederick H. Pough.

The paper describes phenacite crystals from two new localities: Klein-Spitzkopje, Southwest Africa, and Amelia Courthouse, Virginia. Crystallographic study reveals several new forms and two distinct habits on the Klein-Spitzkopje crystals. Accessories on crystals from both localities are compared with those on phenacite from other occurrences.



## COLOR PHOTOGRAPHY IN MINERALOGY, by B. M. Shaub.

The value of natural color illustrations in visual instruction is of paramount importance in teaching subjects in which color is a distinguishing or diagnostic characteristic. Current developments in color transparencies and projection apparatus bring the use of this added and useful factor, color, to the aid of teachers in mineralogy and the allied subjects of optical mineralogy, petrography, gems and precious stones.

The technique of producing color transparencies from natural subjects or from colored illustrations is comparatively simple and does not involve special apparatus in addition to that required to make high quality black and white negatives.

The phenomena of birefringence, optical interference figures, dispersion and other optical properties of crystals can be more intelligently discussed by referring to the particular features under consideration either of the color plate itself or on screen projections. Textures, structures and genetic relationships of the constituent minerals in ores and rocks can be more readily explained to either large or small audiences by natural color illustrations.

These and other ways in which color plates may be adapted to mineralogical instruction will be discussed and illustrated.

## MAGNETITE IN TENNESSEE, by George M. Hall.

A mass of mica peridotite is exposed in Union County, Tennessee. Excellent octahedra of magnetite have been found on the surface as residual material. The basic igneous rock weathers rapidly while the magnetite appears to be very resistant. Also ilmenite and garnet are found associated with the magnetite but careful search did not yield good crystals.

A large part of the mica peridotite area will be flooded when the new dam at Norris is completed.

## BARITE IN THE RED BEDS IN COLORADO, by Arthur L. Howland.

A deposit of barite irregularly replacing a limestone of late paleozoic or Mesozoic age occurs in the southern part of South Park, Colorado. The barite is in coarse arborescent groups with good terminations or in aggregates of tabular crystals, the latter usually having a light blue color. The well developed forms are:  $c(001)$ ,  $m(110)$ , and  $d(102)$ .

OPTICAL PROPERTIES OF IMMERSION LIQUIDS OF THE  $\alpha$ -MONOCHLORNAPHTHALENE: METHYLENE IODIDE SERIES (1.635-1.750), by Newton W. Buerger.

The optical properties of the series  $\alpha$ -monochlornaphthalene: methylene iodide have been studied. The mixing curve shows that the two liquids do not form an ideal solution series. The composition of a liquid of any refractive index within the range, may, however, be calculated with the aid of a correction factor. This correction has been investigated and found to be independent of moderate variations in the indices of the end members. Any liquid and its optical properties may therefore be easily duplicated. Tables and diagrams showing the variations of refractive index with the wave length for the series are given.

## AUSTINITE, A NEW ARSENATE MINERAL FROM GOLD HILL, by Lloyd W. Staples.

This mineral occurs in the oxidized zone closely associated with adamite and limonite, at Gold Hill, Utah. Attention was first called to the probability of its

being a new mineral because of results obtained during the course of microchemical studies on the material. It is a basic arsenate of calcium and zinc with the formula  $\text{CaZn}(\text{OH})\text{AsO}_4$  and belongs to the rhombic disphenoidal class ( $3A_2$ ) of the orthorhombic system. The symmetry was checked by a study of etch figures. The crystals are colorless, have a maximum length of about 1 mm., and most frequently are found to have a scepter habit. There are both right- and left-handed enantiomorphous crystals present. The axial ratio is  $a:b:c=0.657:1:0.832$ . The mineral is named in honor of Professor Austin F. Rogers, of Stanford University.

#### ADAMITE FROM GOLD HILL, by Lloyd Staples.

The adamite is found in the oxidized zone coating limonite, at Gold Hill, Tooele County, Utah. It occurs in two distinct habits, one as individual prismatic orthorhombic crystals that are pale honey yellow, and the other as fan-shaped rosettes that are colorless. The crystals average 1 mm. in length. The indices of refraction are  $\alpha=1.711$ ,  $\beta=1.732$ ,  $\gamma=1.756$ , all  $\pm 0.003$ , which are close to the values found for other localities. A great many crystals were measured and the axial ratio found to be  $a:b:c=0.9742:1:0.7095$  for this material. The new axial ratio lies between the extremes reported from other localities.

#### ENARGITE AND PLUMBOJAROSITE AT PICHER, by Alfred L. Ransome. (Introduced by Austin F. Rogers.)

A large mineral specimen from the Barr Mine, Picher, Oklahoma, is described. It consists primarily of sphalerite, chalcopyrite, and calcite, together with some gypsum, marcasite, covellite, sulphur, quartz, dolomite, galena, and anglesite. Along with the above mentioned minerals are small amounts of enargite and plumbojarosite which heretofore have not been noted from this district. It is thought that the presence of enargite may strengthen the recent theory that the ores are formed by solutions of magmatic origin rather than by meteoric waters.

#### SPHERULITIC CONCRETIONS OF DAHLITE FROM WYOMING, by Duncan McConnell.

Microscopic examination and micro-chemical tests have shown that phosphate nodules, 3-4 cm. in size, from Ishawooa, Park County, Wyoming, are essentially dahllite (calcium carbonophosphate). The concretions are composed of radiating, crystalline dahllite and contain secondary spherulites and axiolites. Phosphate nodules do not ordinarily consist of dahllite nor is their structure ordinarily spherulitic altho in this case the spherulitic structure is well developed and is plumose in form.

### MINERALOGICAL SOCIETY LUNCHEON

#### *Friday Noon, December 28th*

An informal luncheon was held at 1:00 P.M., Friday, December 28th in the Todd Union of the University of Rochester. President John E. Wolff presided and Dr. Alexander H. Phillips acted as toastmaster. Seventy-eight members and visitors attended the luncheon.

### PRESENTATION OF PAPERS CONTINUED

#### *Friday Afternoon, December 28th*

The Society assembled at 2:00 P.M. in joint session with the Geological Society of America for the presentation of petrographic papers, President John E. Wolff presiding. Papers submitted are given in abstract below:

FUSION RELATIONS OF FELDSPATHOIDS, ALKALI FELDSPARS, AND SILICA, by J. F. Schairer and N. L. Bowen.

A study of the system,  $\text{KAlSiO}_4\text{-NaAlSiO}_4\text{-SiO}_2$  yields data of interest to the mineralogist and petrologist. The composition of the nephelites obtained may be expressed in terms of the molecules,  $\text{NaAlSiO}_4$ ,  $\text{KAlSiO}_4$ , and  $\text{NaAlSiO}_8$ . As a result of the incongruent melting of orthoclase the field of leucite extends to compositions considerably richer in silica than orthoclase and all alkali feldspars containing more than 48%  $\text{KAlSi}_3\text{O}_8$  melt incongruently with separation of leucite. The minimum-melting alkali feldspar has approximately the composition Ab 70 Or 30.

METAMORPHIC DIFFERENTIATION AT SERPENTINE-COUNTRY ROCK CONTACTS, by A. H. Phillips and H. H. Hess.

Eskola has outlined the principles of metamorphic differentiation. This article presents examples of such differentiation at contacts between two solid rocks, serpentine and schist or gneiss. Hydrothermal solutions have permitted the migration of material both ways across the contact extracting certain constituents from one side and redepositing them on the other. A small amount of material has probably been brought in by the solutions and likewise material has been carried away by them; but for the most part the differentiation has been merely a redistribution of material already present.

Sharp bands or zones have been produced which are often monomineralic and strikingly different in composition from one another, but composed of minerals stable at the temperature and pressure obtaining and more nearly in equilibrium with their chemical environment (the adjacent rocks) than were the minerals of the original contact. Mineral and chemical compositions of the zones may be very different when formed under different physical conditions. Biotite forms on the country rock side of the contact and actinolite on the serpentine side at high temperatures whereas chlorite and talc, respectively, form at lower temperatures. Tracing the migration of one element, for example, K migrates from the country rock into the biotite zone, but the similarly situated chlorite zone formed at a lower temperature shows a loss of K. Thus migration of various elements during metamorphic differentiation is controlled by physical conditions as well as by the composition of the rocks, involved and, probably to a lesser extent, composition of the incoming solutions.

HYDROTHERMAL MINERALIZATION AT GRAVES MOUNTAIN, by W. D. Johnston, Jr.

Graves Mountain, a quartzite monadnock in the piedmont of eastern Georgia, has long been famous as a collecting ground for rutile, lazulite, and pyrophyllite. Additional minerals are kyanite, ilmenite, hematite, and quartz. Hitherto, the mineralization has been regarded as the result of dynamic regional (mesozone) metamorphism. As the hematite in the quartzite is developed from introduced pyrite, and as the kyanite in the quartzite is commonly marginal to quartz veins and occurs also in them, the writer regards the mineralization as hydrothermal rather than regional.

SCHILLER STRUCTURE, by R. J. Colony.

An inquiry as to the correct usage of the term "schiller structure," with a few illustrations of structures in hornblende which the writer, and others, have called "schiller structure," and which have been described by another group of authors without reference to the term.

True schiller structures in pyroxene are also illustrated and compared briefly with somewhat similar structures in hornblende. The conclusion is reached that only those structures productive of iridescence in incident light in favorably oriented grains in the thin sections, regardless of mineral species, should be called "schiller structures." The term should not be used in describing oriented inclusions that display no iridescence.

TOMICHI DOME FLOW, by J. T. Stark and C. H. Behre, Jr.

Tomichi Dome, an aphanitic igneous mass (T. 49 N., R. 4 E., Colorado) rises 2000 feet above the surrounding country. Generally interpreted as intrusive, it has not hitherto been studied in detail.

"Dome" here refers to topography, not to structure. The underlying beds dip generally southeastward. Overlying rocks are absent. The subjacent sediments range from Dakota to Pierre, but two miles east of the dome the Crookton thrust, dipping east, brings pre-Cambrian beds to the surface. A single sill, quartz-monzonite in composition, cuts the sediments.

The "dome" consists of 1700 feet of flows and breccia similar to the sill mentioned. Topaz is a prominent accessory mineral. Flow lines, phenocrysts with embaying glass, fine texture throughout, the accordance of the igneous mass and the segments, and the absence of baking in underlying rocks, all favor interpreting the mass as a flow.

Significant are (1) the flow nature despite the laccolith-like topographic form and (2) the similarity in composition—hence, probably also in age—of the flow to Laramide intrusive rocks in nearby regions.

GRANITIC INTRUSION IN THE ST. FRANCOIS MOUNTAIN, by Carl Tolman and R. L. Denham.

The igneous rocks of southeastern Missouri can be divided into three general petrographic groups; namely, granites, felsites (porphyry, rhyolite), and basic dike rocks. It was previously thought that the granites graded upward into the felsites, and that both were intruded generally by the basic dikes. More recent work has shown that the granite intrudes the felsite, and data is now accumulating to show that more than one period of intrusion is represented among the granites.

Intrusive relations between granites have been recognized, although the general similarity of the granites of southeastern Missouri and the character of their outcrops tend to make such relations obscure and their recognition difficult. The concept, that a number of intrusions are involved in the granites, and, further, that they are not cognate, is best indicated by Silver Mine and at Skrainka. The relations there indicate not only that two periods of granitic activity but also that sufficient time elapsed between periods for the intrusion of regionally distributed basic bodies. Distinctive accessory mineral assemblages and chemical analyses, as well as general petrographic character, have aided in the differentiation of the granites.

TECHNIQUE FOR THE INVESTIGATION OF ARGILLACEOUS SEDIMENTS, by R. H. Bray, R. E. Grim and P. F. Kerr.

The various methods that have been used to investigate the mineral composition of argillaceous sediments are briefly reviewed. The limitations of these methods as a means of obtaining complete specific data on the mineral composition of these rocks are discussed. A technique for this purpose is described which is based on the re-



moval of soluble salts and absorbed ions followed by dispersion and fractionation into size grades by means of sedimentation and super-centrifuging—the latter method being used to separate the material less than one micron in diameter into three fractions. The mineral constituents of the fractionated portions are identified by x ray, optical, and chemical analyses. The results of the analysis of several argillaceous sediments by means of this proposed method are given together with a discussion to show that a satisfactory complete determination of the mineral constituents, particularly of the finest fractions, is obtainable.

GENETIC RELATIONS OF SPHALERITE IN PEGMATITE, by Clarence S. Ross.

A large mass of sphalerite and albite was encountered in mining feldspar in the McKinney mine near Spruce Pine, N. C. The relations of minerals show that the sphalerite was one of the last to form—being later than albite, quartz, and muscovite, which are secondary.

MICROSCOPIC INVESTIGATION OF FRIEDENSVILLE ZINC ORE, by Donald McCoy Fraser.

The primary sulfides of the Friedensville, Pennsylvania, zinc deposit are sphalerite and pyrite. Their relations indicate that solutions which deposited a “black-jack” variety of sphalerite followed earlier solutions which partially crystallized and partially silicified the dolomitic limestone.

Pyrite shows a variety of contact relations to sphalerite, which are most easily explained by considering the pyrite to have been formed previous to, contemporaneously with, and after the sphalerite. The sulfide minerals occur as replacements of the limestone, as fissure fillings, and together with quartz, dolomite and calcite as the cementing material of limestone breccia present in some of the fractured zones.

Oxidized minerals include smithsonite, calamine, sphalerite, greenockite, goslarite, limonite and melanterite. Gangue minerals are quartz, calcite and dolomite.

The oxidized ore is chiefly concentrated along joints, bedding planes and in solution cavities. For the most part, it occurs as fillings of these openings and fractures but in places it replaces the limestone.

MYLONITIC SPHALERITE FROM FRIEDENSVILLE, PENNSYLVANIA, by Robert D. Butler.

The unique chert-like sphalerite from Friedensville, Pennsylvania, has long been familiar to mineralogists and is in many museum collections. Etched polished sections reveal textural features unlike those due to filling or metasomatic replacement.

A similar sphalerite is found in a quartz-sphalerite vein at Cherryfield, Maine, developed along a small shear zone within the vein, and clearly shows a mylonitic origin. In Maine, an inner zone of fine-grained sphalerite with crushed and drawn-out pyrite and quartz fragments is bordered by a region of sphalerite of intermediate grain size containing interstitial chalcopyrite and pyrrhotite, which, in turn, is bordered by an outer zone of relatively coarse-grained, highly twinned sphalerite containing exsolved chalcopyrite and pyrrhotite, with sphalerite twin lamellae bent and fractured. The fine-grained texture was caused by granulation of a plastically deformed coarse matrix. Recrystallization of strained crystals is shown as another method of new grain development.

At Friedensville, metasomatic replacement is apparent in the wall-rock pyritic sphalerite veinlets, but some of the massive ore is characterized by mylonitic facies, semi-schistose facies, and recrystallized facies. These are related to the deformation,

which preceded the formation of later pyrite and recrystallization of some of the sphalerite. The habits of pyrite and sphalerite, and the texture, are in contrast to the habits and texture in veinlets in the country rock and are quite similar to those observed in the Maine sphalerite. It is concluded that the peculiar chert-like sphalerite from Friedensville was formed by shearing forces which acted on originally coarser-grained sphalerite to produce mylonitic material.

FLUID INCLUSIONS IN SPHALERITE AND GALENA OF THE JOPLIN REGION, by W. S. Tangier Smith.

In the sphalerite of the Joplin region there are two distinct types of fluid inclusions, a larger and a smaller, the former, at least, occurring also in galena. The larger inclusions carry a strong solution of sodium and calcium chlorides, and, in the sphalerite, are opaque and of irregular shape. The smaller are of the ordinary bubble-bearing type of fluid inclusions and of uncertain composition.

Both types of inclusions are found in both primary and secondary sphalerite, and observations indicate that the larger, if not both, are of secondary origin; that they have been formed at normal underground temperatures; that their cavities are due to relatively recent solution; that the liquid of the inclusions is, like the ores themselves, merely a concentrate from dilute solutions; finally, that the concentration from underground waters of small amounts of substances readily soluble in water is not limited to the sulphide ores, but is also to be found in the ore gangues, and even, apparently, in all the rocks of the region, different substances, or differing proportions of the same substances, having been concentrated in different rocks. These concentrations are probably, for the most part, interstitial, rather than in the form of fluid inclusions.

MICA PERIDOTITE IN TENNESSEE, by George M. Hall and H. C. Amick.

Mica peridotite occurs in Union County, Tennessee, in two small areas. Safford, in his *Geology of Tennessee*, described these rocks as metamorphic, and Gordon in an abstract presented at a previous meeting of this society, called attention to the occurrence of mica peridotite. Because of failing health he was unable to finish the necessary field work and complete the paper.

Subsequent study by the writers has shown that the rock crops out in two irregularly shaped masses, surrounded by sedimentary rocks, along a line which extends northeast-southwest. The soil is thick, and the contact with the surrounding rocks is poorly exposed. The irregular outlines of the masses suggest that they are plugs rather than a discontinuous or interrupted dike.

Masses of igneous rock crop out in the vicinity of a fault which brings the Chattanooga black shale (Mississippian) in contact with the Rome shale (Cambrian). The writers collected some fossils from sandy beds which were identified as Helderberg (Becraft). A short distance away similar beds are found at the base of the Hancock (Devonian) dolomite.

The igneous rock is rich in altered biotite, serpentine, and magnetite. Garnet and ilmenite are less abundant. Although prospect pits have been dug in each mass, only altered rock is available.

Igneous masses are apparently intrusive into the Paleozoic rocks, and although some of the Hancock dolomite has apparently been digested, there is little or no evidence of metamorphism of the surrounding rocks. Examination of the rock in the

field and under the microscope shows that the material is, in part, clastic. A brachiopod, in an included piece of dolomite, has been found in the mica peridotite, and under the microscope some organic material closely resembling radiolarian fragments.

METALLOGENETIC RELATIONS OF PORPHYRY AND QUARTZ DIABASE, by Edward Moore Burwash.

This is a tentative presentation of the metallogenetic relations of porphyry and quartz diabase. Facts observed in northern Ontario show: (a) Gold-bearing quartz veins, in nearly all instances, are found genetically related to quartz porphyry, granite porphyry, or syenite porphyry; (b) argentiferous calcite veins are similarly associated with quartz diabase.

General considerations are as follows: (a) Silica is in excess in all these rocks; (b) mineralizers are, therefore, presumably abundant; (c) the normal order of crystallization is reversed; (d) the veinstones correspond to essential magmatic ingredients, the ore-minerals to accessories and fluxes; (e) the order of crystallization is related to (i) fusibility, (ii) solubility, (iii) fluxes.

Tentative conclusions are: (a) The excretion of vein matter (gangue) is prior to the mineralization, but both may be from the same magma; (b) this is due to the order of crystallization.

MONGOLIAN MAGMAS, by George W. Bain.

According to Berkey and Morris, the rocks of inner Mongolia are divided into six main age groups. Their collections are the basis of this laboratory study. Most of the collection was studied petrographically, and 46 specimens, selected to represent the range of types in each group, were analyzed.

Beginning with the Tertiary lava flows, or youngest, each older group shows increasing complexity of secondary structures and increasing simplicity of primary structures. Deuteric and pegmatitic effects are eminently more abundant in all Tertiary rocks than in those of earlier date; in fact, "end stage" activity leaves a progressively more intense mark as younger series are examined.

Chemical analyses show increased content of granitic constituents such as alkalis, especially potash, and diminished content of gabbroic constituents such as lime and magnesia, over all those representing rocks of greater age. Petrographic study allies the granitic constituents with deuteric and pegmatitic minerals. Structural occurrence of this group of minerals suggests that pegmatitic solutions made the granitic rocks, and made later series of rocks increasingly granitic—an explanation of structure more probable than that granite has made the pegmatite.

ORIGIN OF DARK INCLUSIONS IN TONALITE, by Cornelius S. Hurlbut, Jr. (Introduced by E. S. Larsen, Jr.)

The rather uniformly distributed dark inclusions in a tonalite from southern California are flattened and discoidal in nature, showing that they were at one time plastic and have been drawn out and oriented parallel to the flow direction of the rock. Relic minerals and structures found in them point rather conclusively to the fact that the included material was contributed by an older gabbro. After introduction into the tonalite magma, the gabbro fragments have undergone reaction that has rendered them mineralogically similar to the tonalite.

## TRAVERTINE NEAR LEXINGTON, VIRGINIA, by Edward Steidtmann.

Cascade, fan, pool, and channel travertine occur near Lexington, Virginia. Cascade deposits are tough and mossy or algal, the others ashy. Cascade calcite grew on algae and mosses and plainly shows summer and winter layers; the former being thicker, darker, more porous, more vividly fossiliferous, and lower in detritus. Cascade deposits attain 100 feet in thickness, the others 30 feet. The latter, as a rule, are neither algal nor mossy, although they contain organic matter and show numerous banded concretions around tree trunks. Their detrital content is higher and sometimes pebbly.

Travertine is forming now on mosses and algae of the cascades and as an encrustation in the pools. Muddy, deep waters and fixed ice retard algae and mosses, and thereby hinder travertine retention. The plants are favored by clear, shallow, aerated water. By their growth and calcification they create the last two conditions. Muddy waters are now causing erosion to exceed retention.

Feeder spring waters contain from three to four times as much  $\text{CaCO}_3$  in solution as is the case in waters adjusted to the partial  $\text{CO}_2$  pressure of the air. Successive stations downstream show progressive loss of  $\text{CaCO}_3$ , but supersaturation persists even at the foot of cascades 130 feet high. Creek waters became adjusted by vigorous aëration after seven hours, and after two weeks of static exposure.

## GENESIS AND STRUCTURAL RELATIONS OF ABSAROKA VOLCANICS, by John T. Rouse.

Volcanic rocks of the Absaroka Mountains occur in two groups, each group containing a lower acid breccia, a middle basic breccia, and an upper series of basalt sheets. The basalt sheets, because of their relatively uniform thickness over wide areas, serve as a valuable datum plane for determining the structural evolution of the region. The volcanics bury a land surface which, in pre-volcanic time, was quite rough. Field work to date indicates that the volcanic rocks were erupted from many small vents rather than from a few large volcanoes. The pyroclastics are represented by (1) water laid tuffs, (2) explosive volcanic materials, (3) flow breccias, (4) mud flows.

Xenoliths of pre-Cambrian and Paleozoic rocks are abundant in many of the pyroclastics, their distribution in the breccias being closely related to the present outcrops of pre-volcanic rocks. In the basal portion of some of the early acid breccias the majority of the fragments are Paleozoic and pre-Cambrian rocks, whereas in the upper parts of the same breccias the fragments are almost entirely volcanic rocks. This would indicate a blowing out of fragments of the adjacent country rock during the early stage of eruption, whereas the later stage was confined to eruption of volcanic material.

Many large limestone blocks have been found in the early basic breccia, the largest measuring  $200 \times 125 \times 50$  feet. Some structures found in Paleozoic rocks, where they are intimately associated with the volcanics, suggest structural processes which might be analogous to those described by Reeves in the Bearpaw Mountains.

## ROCKS FROM ADELIA LAND AND THE ANTARCTIC ARCHIPELAGO, by Duncan Stewart, Jr.

A quantitative petrographical study was made of the composition of various igneous and metamorphic rocks from Adelia Land and the Antarctic Archipelago, Antarctica.



**GREENALITE**, by Fred Jolliffe.

The examination of rather pure specimens of Mesabi greenalite rock has permitted more exact determinations of the properties of this mineral than have hitherto been made. These allow more definite statements on the nature and origin of the mineral, and on the derivation of some of the Mesabi iron ores therefrom.

The results indicate that greenalite is a definite mineral, distinct from other known species, and having the following properties: Specific gravity 3.0; isotropic;  $N_F 1.686$ ,  $N_D 1.674$ ,  $N_C 1.670$ ; composition closely represented by the formula  $2H_2O \cdot 3FeO \cdot 4SiO_2$ . Its alteration proceeds as follows: (A) to iron oxides and hydroxides by the oxidizing and leaching action of surface waters; (B) to an aggregate of minute green crystals associated with small opaque green masses (herein called metagreenalite) by simple crystallization; (C) to a light-coloured fibrous mineral (possibly a new species) through the agency of magnesium-bearing waters not of surface origin; (D) to an intergrowth of magnetite and amphiboles in the vicinity of heated igneous bodies.

The habit and properties of greenalite strongly indicate that it is of colloidal origin deposited as a chemical precipitate from water which received their iron and silica directly from igneous sources, and that it owes its granule form to purely physical processes (surface tension, osmotic pressure) acting on the semi-fluid gel precipitate.

**ORIGIN AND OCCURRENCE OF FULGERITES IN THE ATLANTIC COASTAL PLAIN**, by Julian J. Petty.

Nearly one hundred occurrences of fulgerite have been found in nine pits in the Cretaceous sands of North and South Carolina. The fulgerites range from  $\frac{1}{8}$  of an inch to 1 inch in diameter, averaging about  $\frac{3}{8}$  of an inch. In cross-section they are either roughly circular, oval or compressed. The external surface is rough with either spiny, corrugated or wing-like projections. The tubes extend nearly vertically downward. They frequently branch and sometimes the branches re-unite. The maximum depth to which they have been traced is about 60 feet. The fulgerites are surprisingly abundant, with an average of several per acre in the areas that could be examined in detail. This abundance is probably explained by the good drainage and the unusually pure quartz sands.

**SHEELITE-BERYL DEPOSIT AT OREANA**, by Paul F. Kerr.

In the spring of 1934 a tungsten bearing pegmatite dike was discovered in the Humboldt Range near Oreana, Nevada, about five miles north of Dumortierite Canyon. The dike varies from two to five feet in width and has been exposed by prospecting for about 2600 feet. Although narrow, it contains high grade concentrations of scheelite which are now being mined by means of a small shaft and tunnels.

The pegmatite occurs along the margin of a quartz-monzonite intrusive. It cuts a much sheared older intrusive presumably a metadiorite and limestone strata of Triassic age. In places the pegmatite grades into a high temperature vein of massive quartz with associated tourmaline. The portions carrying tungsten appear to be a true pegmatite consisting essentially of both massive and crystalline scheelite associated with alkali feldspars, beryl, mica and fluorite. A mineral sequence may be observed with scheelite following beryl and preceding the fluorite stage of mineralization.

## PRESENTATION OF PAPERS CONTINUED

*Saturday Morning, December 29th*

The Society assembled at 9:15 A.M. Saturday, December 29th, for the presentation of papers on sedimentary petrology, chemical mineralogy, crystallography and crystal structure. Eighteen papers were given Saturday morning accompanied by an abundance of enthusiastic discussion particularly in the field of crystallography and crystal structure. President John E. Wolff and Dr. W. S. Bayley divided the task of presiding over the morning session. Papers presented were as follows:

DISTRIBUTION OF THE HEAVY MINERALS IN THE CRETACEOUS CLAYS OF NEW JERSEY, by Alfred C. Hawkins.

Microscopic measurements and counts on elutriated residues from these clays show a systematic distribution of heavy minerals, both stratigraphically and areally, which throws much light upon the origin and details of deposition of the clays and associated sands.

ACCESSORY MINERAL SUITES IN THE GRANITES OF MISSOURI, by Carl Tolman and H. L. Koch. (Presented by permission of the State Geologist of Missouri.)

The accessory mineral residues of 127 samples of the granites of southeastern Missouri have been prepared and examined. The samples were collected not only as representative of possible granitic types and separate intrusions but also to represent a general areal sampling of the granitic rocks as a whole.

The varietal character of the most important primary accessories varied so greatly, both in individual samples and also throughout the granite as a whole, that this feature could not be used as a fundamental basis for the distinction of types. It was found, however, that the different samples showed such differences in kinds and relative amounts of the important accessories as to distinguish well defined groups. The rock groups distinguished on this basis also showed a reasonable constancy in general petrographic character and logical distribution.

DIFFERENTIATION OF THE ONONDAGA FORMATION BY MEANS OF HEAVY MINERALS, by A. E. Alexander.

A recently opened quarry in Erie County, New York, revealed a disconformity in the Onondago formation. (Disconformity is here used in the English sense, following L. D. Stamp.) A one- to two-inch layer of shale sharply defines the chert above from the limestone below. In the coniferous limestone proper, chert nodules are separated from the subjacent limestone by well developed stylolitic structures. Of interest to the mineralogist is the presence of the coral "Favosites," the septae of which are lined with minute calcite crystals. Of interest to the oil geologist is the existence of petroleum in the interstices of this same coral. Small pieces of the oil saturated fossil will burn for a short time following ignition. The investigation of light and heavy mineral fractions is still being continued at present writing.

SYSTEM,  $\text{MgO-FeO-SiO}_2$ , by N. L. Bowen and J. F. Schairer.

Because of the great importance of ferromagnesian silicates as rock-forming minerals, the system,  $\text{MgO-FeO-SiO}_2$ , has been investigated.

No ternary compounds are formed. The system is dominated by three series of solid solutions, the oxide series,  $\text{MgO-FeO}$ , which is complete, the olivine series,

$\text{Mg}_2\text{SiO}_4\text{-Fe}_2\text{SiO}_4$ , likewise complete, and the pyroxene series,  $\text{MgSiO}_3\text{-FeSiO}_3$ , which is only partial, as  $\text{FeSiO}_3$  does not exist as such in the crystalline state, although solid solutions containing nearly 90 per cent of that molecule are formed.

The olivines constitute a simple system of the same type as the plagioclases, which permits calculation of their latent heats of melting.

The pyroxenes are much more complex. They melt incongruently with separation of olivine in the magnesia-rich members and again incongruently in the iron-rich members, but in the opposed manner, i.e., with separation of free silica. In addition, the pyroxenes exhibit two crystalline forms, the orthorhombic (enstatite—hypersthene series), stable at low temperatures, and the monoclinic (clino-enstatite—clino-hypersthene series), stable at higher temperatures.

By reason of the prevalence of solid solution and incongruent melting, fractional crystallization has important consequences.

The optical properties of the solid solution series have been determined.

SYSTEM  $\text{CaO-MgO-SiO}_2$ , by Nelson W. Taylor and Francis J. Williams.

Reactions between solids in the absence of the liquid phase in the system  $\text{CaO-MgO-SiO}_2$  have been investigated. An attempt has been made to reproduce thermal metamorphism and to find what minerals could be produced by thermal treatment alone. Natural minerals, as well as chemically pure oxides and carbonates, were used as raw materials.

The materials were ground, mixed, pressed into discs, and subjected to varying thermal treatment. A sample was heated at each of the following temperatures:  $600^\circ\text{C}$ ,  $800^\circ\text{C}$ ,  $1000^\circ\text{C}$ , and  $1200^\circ\text{C}$ , for 20 hours, and  $1100^\circ\text{C}$  for 104 days. X-ray patterns of the raw materials, their decomposition products, and the desired products were made. The heat-treated specimens were subjected to x-ray analysis to identify their crystalline products. Wollastonite, dicalcium silicate, enstatite, forsterite, monticellite, diopside, and akermanite have been identified from reaction mixtures calculated to give these compounds or other compounds closely related in composition.

These results are correlated with the observations of Harker on thermal metamorphism of siliceous limestones and dolomites, and it is shown that the results of the present work closely parallel Harker's observations.

The mechanism of the reactions between these solids has been shown to be an interdiffusion whose speed depends inversely on the firmness of binding or the structural stability of the reaction product.

X-RAY DATA ON THE SYSTEM  $\text{K}_2\text{SO}_4\text{-MgSO}_4\text{-CaSO}_4$ , by Lewis S. Ransdell.

X-ray powder photographs of fused samples of  $\text{K}_2\text{SO}_4$ ,  $\text{MgSO}_4$  and  $\text{CaSO}_4$  show only a continuous isomorphous series with  $\text{K}_2\text{Mg}_2(\text{SO}_4)_3$  and  $\text{K}_2\text{Ca}_2(\text{SO}_4)_3$  as end-members. No other compounds were observed. The members of this series are simple cubic, with four molecules in the unit cell, and the length of the cube edge varies from  $9.96\text{\AA}$  for the Mg to  $10.36\text{\AA}$  for the Ca end-member.

SYNTHESIS, CONSTITUTION, AND OPTICAL PROPERTIES OF THE NOSELITE-HAUZYNE SERIES, by Tom. F. W. Barth.

The compounds,  $\text{Na}_3\text{Al}_6\text{Si}_6\text{O}_{24}\cdot\text{SO}_4$  and  $\text{Na}_6\text{Ca}_2\text{Al}_6\text{Si}_6\text{O}_{24}(\text{SO}_4)_2$ , were made in silica bombs at  $900^\circ$  and  $1000^\circ$ , respectively. They form the chief constituents of the minerals noselite and hauzyne. New x-ray diffraction data gave conclusive proof

that artificial noselite is isomorphous with  $T^1_d$  and not with  $T^4_d$  as suggested by Machatschki and consequently that Al and Si must appear as variate atoms in a 12-fold position as previously contended by me. (This is shown by reflections from e.g., (111) as well as from various other planes which are systematically extinct in  $T^4_d$ .)

The structure of artificial hauyne can be described in terms of  $T^4_d$  (reflections like (111) are missing), but it is an important fact that the same structure also may be described in terms of  $T^1_d$ , for only in this way can the isomorphous relation to noselite be understood.

The length of the edge of the unit cell,  $a_0$  and the index of refraction,  $n$ , for pure noselite and for pure hauyne are as follows:

	Noselite	Hauyne
$a_0$	9.05	$9.14 \pm 0.01$
$n$	1.450	$1.505 \pm 0.003$

It is worth noting that the refractive index of pure noselite as a consequence of the extremely open structure is lower than that of sodalite.

#### STUDIES IN THE CHROMITE GROUP, by James S. Wishart.

A study of the chromites occurring in a series of related rocks from South Africa shows that with change in composition of the silicate minerals, the composition of the chromite varies. The change in composition is accompanied by slight changes in the physical properties of the chromite.

Study of the analyses indicates that the spinel minerals, especially magnesio- and ferro-aluminates, chromates and ferrates have an order of crystallization which is comparable to the feldspars. This conclusion is supported by a study of occurrences of spinel minerals, by a study of melting points of oxides found in the spinels, and by the melting points of some of the spinels themselves.

Bowen's Y-shaped reaction principle diagram is altered to introduce a series of spinel minerals between the ferro-magnesian silicates and the feldspars.

#### MICROSCOPE OPTICS, by L. V. Foster.

Microscope objectives are made in three degrees of correction. They are apochromatic, semi-apochromatic, and achromatic. Microscope eyepieces are made in varying degrees of achromatism. These characteristics will be described and it will be shown how combinations can be chosen to secure the best general results.

#### USE OF THE TERM SYNGONY IN GEOMETRICAL CRYSTALLOGRAPHY, by Austin F. Rogers.

Simple, accurate definitions of the six crystal systems may be given in terms of the four known types of zones: clinogonal, orthogonal, tetragonal, and hexagonal. Of these all but the clinogonal retain their special character with change of temperature. Since temperature is taken into account, this means that crystal system is a physical-geometrical concept.

Instead of using the term syngony as a synonym of crystal system, as Fedorov does, it seems better to employ it in a purely geometrical sense. Syngony then is used not only for the various symmetry classes of a given system, but also for crystals of other systems which temporarily have the geometrical requirements of the given system at a specified temperature.

The name of the system furnishes a name for the syngony characteristic of the system. And to the six syngonies thus defined there is added a seventh, the *diclinic*,



formerly used as a system name, but here revived for the particular syngony in which one of the interzonal angles  $\alpha$ ,  $\beta$  or  $\gamma$  is  $90^\circ$ .

Crystals of the triclinic system may have either triclinic, diclinic, monoclinic, or orthorhombic syngony; examples of all of these are known. Asymmetric and centrosymmetric crystals are assigned to the triclinic system regardless of the type of syngony but the characteristic syngony is triclinic. And similarly for the five remaining systems, syngonies other than the characteristic one may be given.

The concept of syngony here set forth is believed to be important in advanced geometrical crystallography.

#### CRYSTALLOGRAPHY OF MULLITE, by Harry Berman.

Artificial mullite crystals having a good prism zone and a single terminal form yielded the crystallographic elements  $a:b:c=.982:1:.752$ . These values are sufficiently near to sillimanite elements to indicate that one cannot distinguish the two crystallographically. The crystallographic elements differ only slightly from those earlier found by x-ray methods.

#### CRYSTAL CLASSIFICATION AND SYMBOLISM, by D. Jerome Fisher.

The chief object of this paper is to present a classification of crystals in which these bodies are so arranged that existing symbolism and nomenclature are more readily comprehended. This is done by means of a chart with columns based on axes and axes-planes, according to Schoenflies' divisions for point-group nomenclature, and rows based primarily on the symmetry of the crystal axes. Controversial matters and recent terminology of Europeans are discussed in the light of a brief historical treatment of the subject.

#### DERIVATION OF THE FOURTEEN BRAVAIS SPACE-LATTICES, by Lewis S. Ramsdell.

The fourteen space-lattices are derived in an elementary way from the two fundamental properties of crystals, namely, homogeneity and variation of properties with direction.

#### CRYSTAL STRUCTURE OF CALAVERITE, by G. Tunell and C. J. Ksanda.

Crystals of calaverite from Cripple Creek, Colorado, have been studied by means of the Weissenberg x-ray goniometer (with use of Cr— and Cu— radiation) and by means of the two-circle reflection goniometer; powder spectrum photographs have also been made with Cr—, Fe—, Cu—, and Mo— radiation. The structural lattice has elements analogous to the fundamental morphological elements of Goldschmidt, Palache, and Peacock (their S—elements). X-ray analysis shows that there are two “molecules” of  $\text{AuTe}_2$  in the unit cell. Goldschmidt, Palache, and Peacock concluded that calaverite belongs to the monoclinic system; the systematic extinctions of the x-ray diffraction effects on our films limit the monoclinic space groups possible for calaverite to three,  $\text{C2/m}$  ( $\text{C}_{2h}^3$ ),  $\text{C2}$  ( $\text{C}_2^3$ ),  $\text{Cm}$  ( $\text{C}_s^3$ ), the extinctions of these three space groups being identical. By means of the intensities alone all arrangements in  $\text{Cm}$  have been excluded. The arrangement of the atoms in calaverite can be realized in either the space group  $\text{C2/m}$  or  $\text{C2}$  and the values of the parameters have been determined by means of the intensities of the diffraction lines alone.

#### FRIEDEL'S LAW OF MEAN INDICES, by J. D. H. Donnay.

By means of this law, approximate values for the axial elements can be computed

from the list of observed forms (without measuring any interfacial angle on the crystal).

According to G. Friedel, the Law of Mean Indices holds good independently of the choice of the primitive form. This statement does not appear to be valid in all cases, as shown by examples.

CRYSTALLOGRAPHIC EXPRESSION OF RESULTS OF THE THEORY OF SPACE GROUPS,  
by W. V. Howard.

In order to demonstrate the close relationship which exists between the external and internal symmetry of substances, it is proposed to change the position of the origin in the analytical expression of the results of the theory of space groups to the center of the cell. In this way, the special positions are found to have a close relation, not only to the crystal forms existing in the crystal classes to which the space groups belong, but also to the important planes determined during *x*-ray analysis.

Consideration is also given to the symmetry of the equivalent positions with a view to establishing a much closer relation between the internal and external symmetry of substances than appears to exist at present.

It is believed that the proposed coordinates will also greatly simplify the determination of the space group and the positions of the atoms following *x*-ray analysis.

CHOICE OF CRYSTALLOGRAPHIC ELEMENTS, by M. A. Peacock.

The choice of crystallographic elements is controlled by certain generally accepted conventions and a number of partly conflicting guiding principles in the use of which there is naturally a lack of agreement. The following principles are distinguished and briefly discussed: highest real symmetry; highest pseudosymmetry; simplest cleavages; simplest indices; complication; reticular density; structure cell; isomorphism and homeomorphism. A general procedure leading to satisfactory elements is outlined but the adoption of a set of fixed rules is avoided. Such rules have practical value outside the field of mineralogy, but they do not solve a problem whose real solution still lies in the little-studied relations between the form and structure of crystals.

APPLICATION OF PLANE GROUPS TO THE INTERPRETATION OF WEISSENBERG  
PHOTOGRAPHS, by M. J. Buerger.

The Weissenberg method makes it possible to investigate the reciprocal lattice of a crystal directly. Each Weissenberg photograph is a projection of a single plane of the reciprocal lattice which embodies both point-group and translation-group properties. All possible Weissenberg patterns can therefore be predicted from a systematic study of plane point-groups and plane translation-groups. There are 10 plane point-groups, each giving a unique Weissenberg distribution of reflection positions and intensities. A few appropriately chosen photographs permit an unequivocal determination of the centrosymmetrical symmetry class of the crystal investigated. Suitable tables are provided for this purpose. There are 5 plane translation-groups. It is shown that these lead to 15 possible Weissenberg patterns, each a projection of a possible reciprocal lattice level. A few appropriately chosen photographs provide data for a unique determination of the reciprocal lattice type, from which the particular Bravais lattice type follows at once. Suitable tables for this

purpose have been prepared. This method is purely geometrical and avoids analytical procedure, including indexing of reflections. The similar projection properties of the equi-inclination beam Weissenberg method, makes it possible to determine the Bravais lattice without construction, by the inspection of several Weissenberg negatives, singly and superposed. The same methods may be applied to the determination of the space group.

The reading of the papers was completed at 1:00 P.M. It was moved by Dr. Waldemar T. Schaller, seconded by Dr. Walter F. Hunt and voted unanimously that the following resolution be inscribed upon the minutes of the meeting and a copy be sent to Dr. Harold L. Alling, Chairman of the Local Committee:

"The membership of the Mineralogical Society of America wishes to express its appreciation of the extremely cordial entertainment, the efficient arrangement and operation of facilities for the meetings and the generous hospitality of the Local Committee of the University of Rochester."

With no further business to come before the Society, President John E. Wolff declared the meeting adjourned at 1:05 P.M.

At various times during the sessions of the Society, the following persons registered their attendance. In addition there were many others whose names were not recorded.

Alice S. Allen	E. N. Cameron	D. J. Fisher
Andrew G. Alpha	Grace M. Carhart	Frank C. Foley
J. W. Ambrose	R. W. Chapman	W. F. Foshag
Olaf Andersen	J. R. Chelikowsky	L. V. Foster
R. J. Anderson	J. W. Coburn	Dean F. Frasché
	Wm. B. Colburn	Donald M. Fraser
Geo. W. Bain	R. J. Colony	B. C. Freeman
J. D. Barksdale	Mary E. Cooley	A. H. Fretz
Tom. Barth	John R. Cooper	
A. M. Bateman		Alton Gabriel
W. S. Bayley	A. L. Day	Joseph L. Gillson
C. H. Behre, Jr.	W. C. Dennis	Jewell Glass
G. K. Bell, Jr.	M. V. Denny	C. E. Gordon
Marland P. Billings	J. D. H. Donnay	L. C. Graton
Bennett Frank Bine	Edward C. Dopples	O. R. Grawe
N. L. Bowen	J. L. Dyson	Ralph E. Grim
S. R. Brockmier		
J. L. Browne	R. S. Edmundson	E. P. Hall
A. F. Buddington	R. C. Emmons	George M. Hall
M. J. Buerger	George L. English	A. C. Hawkins
Newton W. Buerger	Maurice Ewing	J. S. Hawley
J. D. Burfoot		E. P. Henderson
R. D. Butler	A. D. Falck, Jr.	H. H. Hess
E. M. Burwash	G. T. Faust	Wm. O. Hickok
	C. N. Fenner	Ralph J. Holmes
C. K. Cabeen	Chas. R. Fettke	A. P. Honess
C. E. Cairner	Sue Fields	Henry Hotchkiss

- |                     |                          |                     |
|---------------------|--------------------------|---------------------|
| J. L. Hough         | V. R. Page               | C. B. Slawson       |
| W. V. Howard        | C. Palache               | Dudley T. Smith     |
| A. L. Howland       | Elwyn L. Parry           | Hugh S. Spence      |
| W. F. Hunt          | A. L. Parsons            | L. E. Spock         |
| C. S. Hurlburt, Jr. | M. A. Peacock            | Leonard H. Starbird |
| D. E. Jensen        | Joe Webb Peoples         | H. T. Stark         |
| Albert Johannsen    | S. S. Philbrick          | D. W. St. Clair     |
|                     | Alexander H. Phillips    | Edw. Steidtmann     |
|                     | F. H. Pough              | E. H. Stevens       |
|                     | G. W. Prescott           | Duncan Stewart, Jr. |
|                     |                          | R. W. Stone         |
| R. W. Karpinski     | A. W. Quinn              |                     |
| Paul F. Kerr        |                          | Nelson W. Taylor    |
| Louise Kingsley     | Lewis S. Ramsdell        | Ellis Thomson       |
| Edward H. Kraus     | R. D. Reed               | C. Tolman           |
| Lois A. Kremer      | W. A. Rice               | George Tunell       |
| Philip Krieger      | John L. Rich             |                     |
| P. D. Kryne         | H. Ries                  | Stephen Varni       |
|                     | Austin F. Rogers         | J. S. Vhay          |
| E. S. Larsen        | Clarence S. Ross         | H. N. Vieweg        |
| Harriet Lee         | J. T. Rouse              |                     |
| J. B. Lucke         | Chalmer J. Roy           | Allen W. Waldo      |
|                     | J. J. Runner             | T. L. Walker        |
| J. P. Marble        |                          | Freeman Ward        |
| James H. C. Martens | Edward Sampson           | E. Wight            |
| J. E. Maynard       | J. F. Schairer           | Kenneth P. Wilson   |
| Evans B. Mayo       | W. T. Schaller           | A. N. Winchell      |
| G. R. Megalklin     | Marion R. Schmidt        | H. W. Winchell      |
| Benj. L. Miller     | B. M. Shaub              | James S. Wishart    |
| Ralph L. Miller     | Joseph T. Singewald, Jr. | John E. Wolff       |
| Anna Minkofski      | Quentin D. Singewald     |                     |
| Chas. B. Moke       | D. C. Skeels             | John A. Young, Jr.  |
| Berlen C. Moneymoke |                          |                     |
| E. S. Moore         |                          |                     |
| James F. Morton     |                          |                     |



## LIST OF FORMER OFFICERS AND MEETINGS WITH DATES

By recommendation of the Council, a complete list of past officers is printed in the proceedings of the annual meeting of the Society.

HONORARY PRESIDENT for life.....Edward S. Dana, 1925

### PRESIDENTS

1920 Edward H. Kraus  
1921 Charles Palache  
1922 Thomas L. Walker  
1923 Edgar T. Wherry  
1924 Henry S. Washington  
1925 Arthur S. Eakle  
1926 Waldemar T. Schaller  
1927 Austin F. Rogers  
1928 Esper S. Larsen  
1929 Arthur L. Parsons  
1930 Herbert E. Merwin  
1931 Alexander H. Phillips  
1932 Alexander N. Winchell  
1933 Herbert P. Whitlock  
1934 John E. Wolff

### VICE-PRESIDENTS

1920 Thomas L. Walker  
1921 Waldemar T. Schaller  
1922 Frederick A. Canfield  
1923 George F. Kunz  
1924 Washington A. Roebling  
1925 Herbert P. Whitlock  
1926 George Vaux, Jr.  
1927 George L. English  
1928 Lazard Cahn  
1929 Edward Wigglesworth  
1930 John E. Wolff  
1931 William F. Foshag  
1932 Joseph L. Gillson  
1933 Frank N. Guild  
1934 W. A. Tarr

### SECRETARIES

1920-1922 Herbert P. Whitlock  
1923-1933 Frank R. Van Horn  
1933-1934 Albert B. Peck  
1934- Paul F. Kerr

### TREASURERS

1920-1923 Albert B. Peck  
1924-1929 Alexander H. Phillips  
1929-1930 Albert B. Peck  
1931- Waldemar T. Schaller

### EDITORS

1920-1921 Edgar T. Wherry  
1922- Walter F. Hunt

### COUNCILLORS

1920 Arthur S. Eakle, Frank R. Van Horn, Fred E. Wright, Alexander H. Phillips.  
1921 Frank R. Van Horn, Fred E. Wright, Alexander H. Phillips, Austin F. Rogers.  
1922 Fred E. Wright, Alexander H. Phillips, Austin F. Rogers, Thomas L. Watson.  
1923 Alexander H. Phillips, Austin F. Rogers, Thomas L. Watson, Esper S. Larsen.  
1924 Austin F. Rogers, Thomas L. Watson, Esper S. Larsen, Arthur L. Parsons.  
1925 Thomas L. Watson, Esper S. Larsen, Arthur L. Parsons, William F. Foshag.  
1926 Esper S. Larsen, Arthur L. Parsons, William F. Foshag, William A. Tarr.  
1927 Arthur L. Parsons, William F. Foshag, William A. Tarr, Alexander N. Winchell.  
1928 William F. Foshag, William A. Tarr, Alexander N. Winchell, Ellis Thomson.  
1929 William A. Tarr, Alexander N. Winchell, Ellis Thomson, Clarence S. Ross.  
1930 Alexander N. Winchell, Ellis Thomson, Clarence S. Ross, Paul F. Kerr.  
1931 Ellis Thomson, Clarence S. Ross, Paul F. Kerr, William S. Bayley.  
1932 Clarence S. Ross, Paul F. Kerr, William S. Bayley, William J. McCaughey.

- 1933 Paul F. Kerr, William S. Bayley, William J. McCaughey, Kenneth K. Landes.  
 1934 William S. Bayley, William J. McCaughey, Kenneth K. Landes, E. P. Henderson.

## ANNUAL MEETING PLACES

- 1920 Chicago, Illinois  
 1921 Amherst, Massachusetts  
 1922 Ann Arbor, Michigan  
 1923 Washington, D.C.  
 1924 Ithaca, New York  
 1925 New Haven, Connecticut  
 1926 Madison, Wisconsin  
 1927 Cleveland, Ohio  
 1928 New York, New York  
 1929 Washington, D.C.  
 1930 Toronto, Canada  
 1931 Tulsa, Oklahoma  
 1932 Cambridge, Massachusetts  
 1933 Chicago, Illinois.  
 1934 Rochester, New York.

HONORARY LIFE FELLOWS OF THE MINERALOGICAL  
SOCIETY OF AMERICA

- \* Brauns, Reinhard, University of Bonn, Germany.  
 \* Brögger, Waldemar C., University of Oslo, Oslo, Norway.  
 \* Lacroix, A., Museum of Natural History, Paris, France.  
 \* Spencer, L. J., Mineralogical Department, British Museum, Cromwell Road,  
 London, S.W.7., England.

LIST OF FELLOWS AND MEMBERS OF THE MINERALOGICAL  
SOCIETY OF AMERICA<sup>1</sup>

(\* Indicates Fellow)

- \* Adams, Elliot Q., Lamp Development Lab., Nela Park, Cleveland, Ohio.  
 \* Agar, William M., Dept. of Geology, Columbia University, New York, N.Y.  
 Ahlfeld, Friedrich, Marbury a Lahn, Germany.  
 Alexander, A. E., 159 Goulding Avenue, Buffalo, New York.  
 Allen, Frederick I., 55 East 65th Street, New York, N.Y.  
 \* Allen, Victor T., St. Louis University, 221 N. Grand Blvd., St. Louis, Missouri.  
 \* Alling, Harold L., 31 Barrington St., Rochester, New York.  
 Amílcar, Mario de Jesus, Institute Superior Tecnico, Lisboa, Portugal.  
 \* Aminoff, Gregori, Riksmuseet, Stockholm 50, Sweden.  
 \* Andersen, Olaf, Research Lab., U.S. Steel Corp., Kearny, New Jersey.  
 Anderson, B. W., The Laboratory, The London Chamber of Commerce, 55,  
 Hatton Garden, London, E. C. 1, England.

<sup>1</sup> The names and addresses here listed are those on record January 1st, 1935.  
 Any omission or correction should be sent to the Secretary, Dr. Paul F. Kerr, Department of Geology and Mineralogy, Columbia University, New York, N.Y.

- Anderson, Chas. A., Dept of Geology and Mineralogy, University of California, Berkeley, California.
- Andrews, Gerald, Dept. of Geology, Egyptian University, Cairo, Egypt.
- Andrews, Walter S., R.F.D. #2, Oakland, Maine.
- Armstrong, L. K., 704 Peyton Bldg., Spokane, Washington.
- \* Ashcroft, Frederick Noel, 1 Egerton Gardens, South Kensington, S.W. 3, London, England (Life Fellow).
- Atkins, Frank P., Jr., 2207 Upland Place, Walnut Hills, Cincinnati, Ohio.
- Ayers, Vincent L., Michigan College of Mines and Technology, Houghton, Michigan.
- Bailey, E. M., Andover, Maine.
- Baker, J. Willard, R. F. D. No. 1, Wrentham, Massachusetts.
- Balke, Claire C., 40 Deere Park Drive South, Highland Park, Illinois.
- Bandy, Mark C., 81 Perkins Hall, Harvard University, Cambridge, Massachusetts.
- Bannerman, H. M., Dartmouth College, Hanover, New Hampshire.
- Barbour, Gordon, Bol-Inca Mining Corp., Chanin Bldg., New York, N.Y.
- Barlett, Helen Blair, c/o A. C. Spark Plug Co., Flint, Michigan.
- Barrett, Harvey P., P.O. Box 43, Charlotte, North Carolina.
- Barrett, Richard L., 11308 Hessler Rd., Station E., Cleveland, Ohio.
- \* Barth, Tom. F. W., Geophysical Laboratory, Washington, D.C.
- \* Bascom, Miss F., R.F.D. No. 3, North Adams, Massachusetts.
- Bateman, Alan M., Dept. of Geology, Yale University, New Haven, Connecticut.
- \* Bauer, L. H., New Jersey Zinc Co., Franklin, New Jersey.
- \* Bayley, William S., Dept. of Geology, University of Illinois, Urbana, Illinois.
- Berry, G. P., 849 15th St., A., Moline, Illinois.
- Behre, Chas. H., Jr., Dept. of Geology, Northwestern University, Evanston, Illinois.
- Berger, Anton, Modling bei Wien, Hauptstrasse 24, Austria.
- \* Berman, Harry, 12 Geological Museum, Harvard University, Oxford Street, Cambridge, Massachusetts.
- Bernheimer, Alan W., 2259 N. Park Ave., Philadelphia, Pennsylvania.
- Billings, Marland, 22 Burroughs St., Jamaica Plains, Massachusetts.
- Birdsey, B. A., Creede, Colorado.
- Blank, Eugene W., 241 North Ninth St., Allentown, Pennsylvania.
- Blank, Horace R., U. S. Geological Survey, Post Office Bldg., Jamaica, New York.
- Blumenthal, Maurice, 558 Quincy St., Brooklyn, New York.
- Boatner, H. 420 Woodruff Bldg., Springfield, Missouri.
- Bogert, Joseph, 1826 Turner St., Allentown, Pennsylvania.
- \* Bøggild, O. Mineralogical Museum, University of Copenhagen, Copenhagen, Denmark.
- Born, Kendall E., Dept of Geology, Washington University, St. Louis, Missouri.
- Boubée, Nérée, 3 Boulevard et Place St. Andre-des-Arts, Paris, France.
- \* Bowen, N. L., Geophysical Laboratory, Washington, D.C.
- \* Bowles, Oliver, Building Material Division, U.S. Bureau of Mines, Washington, D.C.
- Boyle, J. C., 225 Kenmore Road, Brookline Upper Darby, Pennsylvania.

- Bradley, F. F., 2466 Broadway, Toledo, Ohio.
- Bradley, J. W., 1206 Pacific Mutual Bldg., Low Angeles, California.
- Brant, Arthur M., Lord Hall, Ohio State University, Columbus, Ohio.
- Brendler, W., Chemisches Mineralogisches Laboratorium, Hamburg 23, Marien-taler Str. 142, Germany.
- \* Bruce, E. L., Dept. of Mineralogy, Queen's University, Kingston, Ontario, Canada.
- \* Buddington, Arthur F., Princeton University, Princeton, New Jersey.
- \* Buerger, Martin J., Room 4-346, Massachusetts Institute of Technology, Cam-bridge, Massachusetts.
- Buerger, Newton W., Room 4-346, Dept. of Geology, Massachusetts Institute of Technology, Cambridge, Massachusetts.
- Bunton, Paul B., Room 602, Transportation Bldg., Washington, D.C.
- \* Burbank, Wilbur S., U.S. Geological Survey, Golden, Colorado.
- Burfoot, James Dabney, Jr., Dept. of Geology, Cornell University, Ithaca, New York.
- Butler, B. T., Room 316 Main Bldg., College of the City of New York, 139th St. and Convent Ave., New York, N.Y.
- \* Butler, G. M., University of Arizona, Tucson, Arizona.
- Butler, Robert D., Dept of Geology, Massachusetts Institute of Technology, Cambridge, Massachusetts.
- \* Buttgenbach, Henry J., 13 Quai de Rome, Liege, Belgium.
- \* Cahn, Lazard, 510 Exchange National Bank Bldg., Colorado Springs, Colorado.
- Callahan, J. E., 21 Acre Lane, Brixton, London, S.W. 2, England.
- Callahan, William H., Austinville, Virginia.
- Cameron, Eugene N., Dept. of Geology, Washington Square College, New York University, New York, N.Y.
- Campbell, Charles D., Box 943, Stanford University, California.
- Campbell, Ian, Dept. of Geology, California Institute of Technology, Pasadena, California.
- Capps, Mrs. Washington L., 1823 Jefferson Place N. W., Washington, D.C.
- Carhart, Grace M., Hunter College, Bedford Park Boulevard and Navy Ave., New York, N.Y.
- Carobbi, Guido, Instituto di Mineralogia, R. Universita, Moderna, Messina, Italy.
- Case, L. V., #1 Grove St., Tarrytown, New York.
- Chadbourn, E. R., 394 Pleasant St., Melrose, Massachusetts.
- Chase, Hugh D., Unity, Maine.
- Cienkowski, Edmund H., 6903 Bustleton Ave., Philadelphia, Pennsylvania.
- Clinton, Henry G., Box C., Manhattan, Nevada.
- Codazzi, Ricardo L., P.O. Box 965, Bogota, Columbia, South America.
- Colburn, Burnham S., Greystone Court, Biltmore, North Carolina.
- Colburn, William B., 333 Washington Rd., Grosse Pointe, Michigan.
- \* Colony, R. J., Dept. of Geology, Columbia University, New York N.Y.
- \* Connolly, Joseph R., 1301 Eleventh St., Rapid City, South Dakota.
- Conover, Ramon, Box 35, Kyserike, Ulster County, New York.
- Cooley, Miss Mary E., Dept. of Geology, Mount Holyoke College, South Hadley, Massachusetts.



- \* Corbett, Clifton S., Gulf Oil Company, Room 1646, 17 Battery Place, New York, N.Y.
- Correns, Dr., Mineralog.-geolog. Institut, Universitat Rostock, Wismarsche Str. 8, Rostock, Mecklinburg-Swerin, Germany.
- Cox, Walter Y., 2611 Hartzell St., Evanston, Illinois.
- Crawford, Arthur L., 1067 East 5th St. South, Salt Lake City, Utah.
- \* Crawford, R. D., 1050 Tenth St., Boulder, Colorado.
- Crickman, G. W., 425 State Capitol, Atlanta, Georgia.
- Currier, L. W., U. S. Geological Survey, Washington, D.C.
- Curtis, Algernon Lewin, Westmoor Laboratory, Chatteris, England.
- Curtis, Peter L., Skagg Springs, California.
- Dake, H. C., 2385 N. W. Thurman St., Portland, Oregon.
- \* Dana, E. S., 24 Hillhouse Ave., New Haven, Connecticut.
- Davidson, Stanley C., 170 McNaughton St., Sudbury, Ontario, Canada.
- Decius, L. C., 79 New Montgomery St., San Francisco, California.
- Denny, M. V., Mineralogical Laboratory, University of Michigan, Ann Arbor, Michigan.
- Diaz, Carlos, A., Cassilla 60, La Serena, Chile, South America.
- Dings, McClelland, 1043 Soldano Avenue, Azusa, California.
- \* Dodge, Francis D., 69 Avenue A., Bayonne, New Jersey.
- Dodge, Mrs. Nora P., 515 Fourth St., Oakmont, Pennsylvania.
- Dodge, Theodore A., Wigglesworth E 12, Cambridge, Massachusetts.
- \* Donnay, J. D. H., Johns Hopkins University, Baltimore, Maryland.
- Doten, Robert K., 53 Garfield St., Cambridge, Massachusetts.
- \* Eckel, Edwin B., U. S. Geological Survey, Washington, D.C.
- Eggleston, Julius W., Cuttingsville, Vermont.
- Ehrmann, Martin L., 700 West 176th St., New York, N.Y.
- Ellis, T. K., Bay Shore, L. I., New York.
- \* Ellsworth, H. V., Geological Survey, Ottawa, Canada.
- Elwell, Wilbur J., R. F. D. No. 4, Box 18, Danbury, Connecticut.
- Emery, Alden H., U. S. Bureau of Mines, Washington, D.C.
- \* Emmons, R. C., Science Hall, University of Wisconsin, Madison, Wisconsin.
- Engel, Rene, California Institute of Technology, Pasadena, California.
- \* English, George L., 50 Brighton St., Rochester, New York.
- Fahey, J. J., U. S. Geological Survey, Washington, D.C.
- Fairchild, J. G., U. S. Geological Survey, Washington, D.C.
- Farnham, C. Mason, 3032 Cambridge Place, Washington, D.C.
- Faust, G. T., 1520 West Susquehanna Ave., Philadelphia, Pennsylvania.
- \* Fettke, Charles R., 1118 Wightman St., Squirrel Hill Station, Pittsburgh, Pennsylvania.
- \* Fisher, D. Jerome, Dept. of Geology, University of Chicago, Chicago, Illinois.
- Fisher, Lloyd W., Dept of Geology, Bates College, Lewiston, Maine.
- Fisk, Henry G., Universal Portland Cement Co., Buffington, Indiana.
- Flack, Wylie H., 428 Tyson Ave., Philadelphia, Pennsylvania.
- Ford, Hugh Alex., British Consulate General, Room 724, Post Office Square, Boston, Massachusetts.

- \* Ford, W. E., 876 Yale Station, New Haven, Connecticut.
- \* Foshag, William F., Division of Mineralogy, U. S. National Museum, Washington, D.C.
- Fraser, Donald McCoy, Dept. of Geology, Lehigh University, Bethlehem, Pennsylvania.
- Fretz, A. H., 42 West Market St., Bethlehem, Pa.
- Fronzel, Clifford, 3822-217th St., Bayside, Long Island, New York.
- Fuller, Richard E., 1642 Federal Ave., Seattle, Washington.
- Furcron, A. S., Dept. of Geology, Western Reserve University, Cleveland, Ohio.
  
- Gabriel, Alton, Bureau of Mines, New Brunswick, New Jersey.
- \* Gage, R. B., Box 199, Trenton, New Jersey.
- Gallagher, David, 349 Clark Road, Brookline, Mass.
- \* Gillson, Joseph L., Room 8060, Dupont Bldg., Wilmington, Delaware.
- \* Gilluly, James, U. S. Geological Survey, Washington, D.C.
- Glass, Miss J. J., U. S. Geological Survey, Washington, D.C.
- \* Gonyer, Forest A., Dept. of Mineralogy, Harvard University, Cambridge, Massachusetts.
- Goranson, E. A., Base Metals Mining Corp., Ltd., Field, B. C., Canada.
- \* Gordon, Samuel G., Academy of Natural Sciences, Logan Circle, Philadelphia, Pennsylvania.
- Gordon, William Thomas, Kings College, Strand, London W. C. 2, England.
- Graeber, Charles K., Pennsylvania Geological Survey, Harrisburg, Pennsylvania.
- \* Graham, R. P. D., McGill University, Montreal, Canada.
- Graton, L. C., Harvard University, Cambridge, Massachusetts.
- Grawe, Oliver R., School of Mines and Metallurgy, Rolla, Missouri.
- Green, Frank T., 1176 Fell St., San Francisco, California.
- Greenland, C. W., Box 1242, Timmins, Ontario, Canada.
- Gregory, Albert G. F., "Melrose," Woodchurch, Ashford, Kent, England.
- Greig, J. W., Geophysical Laboratory, 2801 Upton St., N. W., Washington, D.C.
- Grenzig, J. G., 219 Lincoln Ave., Brooklyn, New York.
- Grieger, J. M., 405 Ninita Parkway, Pasadena, California.
- Grim, Ralph E., Illinois Geological Survey, Urbana, Illinois.
- Grosholz, Gustave, Zasius Strasse 30, Freiburg in Breisgau, Germany.
- \* Gruner, John W., Dept. of Geology and Mineralogy, University of Minnesota, Minneapolis, Minnesota.
- Guerrlich, Francis, P. O. Box 805, Stamford, Connecticut.
- \* Guild, Frank N., 107 Olive Rd., Tucson, Arizona.
- Gunnell, E. M., 595 East Losey St., Galesburg, Illinois.
  
- Hall, F. P., 206 Granger Rd., R. F. D. No. 4, Syracuse, New York.
- \* Hall, George M., Dept. of Geology, University of Tennessee, Knoxville, Tennessee.
- Hammer, Alfred E., Malleable Iron Fittings Co., Branford, Connecticut.
- Hanley, John B., 323 Main Street, Lewiston, Maine.
- Harrassowitz, Otto, Querstrasse 14, Leipzig, C 1, Germany.
- Hart, W. C., 101 Ruxton St., Manitou, Colorado.
- Hartley, B. W., Haileybury, Ontario, Canada.

- \* Hawkins, A. C., 300 Livingston Ave., New Brunswick, New Jersey.
- \* Hawley, James E., Dept. of Mineralogy, Queen's University, Kingston, Ontario, Canada.  
Heineman, Robert E. S., 1633 E. Hawthorne St., Tuscon, Arizona.
- \* Henderson, Edward P., Dept. of Geology, U. S. National Museum, Washington, D.C.
- \* Hess, Frank L., U. S. Bureau of Mines, 1221 Newton St. N. E., Brookland, D.C.  
Hess, Harry H., Dept. of Geology, Princeton University, Princeton, New Jersey.
- \* Hewett, Donnel Foster, U. S. Geological Survey, Washington, D.C.  
Hewitt, L. C., c/o Laclede Christy Clay Products Co., 4705 Ridgewood, St. Louis, Missouri.  
Heyl, George R., Graduate College, Princeton University, Princeton, New Jersey.  
Hickok, William O., 4th 1409 N. Front Street, Harrisburg, Pennsylvania.
- Hills, Thomas McD., Dept. of Geology, Vassar College, Poughkeepsie, New York.
- Hirsch, Dipl. Ing. Willy, Fürstenstrasse 22, I<sup>e</sup>, München, Germany.  
Hirschi, Hans, Spiez, Switzerland.
- \* Hodge, E. T., 2915 Luray Terrace, N. W., Portland, Oregon.
- Holden, Guerdon S., Plain Dealer Building, Cleveland, Ohio (Life member).
- \* Holmes, Arthur, Science Lab., South Road, Durham, England.  
Holmes, Lindsay D., 57 West 9th St., New York, N.Y.  
Holmes, Ralph J., 419 West 115th St., New York, N.Y.
- \* Honess, Arthur P., 113 Frazier St., State College, Pennsylvania.  
Horn, Aubrey E., Loup House, Axminster, Devon, England.  
Howard, W. V., Dept. of Geology, University of Illinois, Urbana, Illinois.  
Howland, Arthur L., Dept. of Geology, Northwestern University, Evanston, Illinois.  
Hugill, Wm., Langham House, Fields Road, Alsager, Cheshire, England.
- \* Hunt, Walter F., Mineralogical Lab., University of Michigan, Ann Arbor, Michigan.  
Hurst, George D., 322 W. 56th Street, New York, N.Y.
- \* Insley, Herbert, Industrial Bldg., Bureau of Standards, Washington, D.C.  
Ito, Taneo, c/o Senko-Gakukyoshitsu, Kogakubu, Hokkaido Teikoku Daigaku Sapporo, Hokkaido, Japan.
- Jacob, Walter P., 2445 Graybar Bldg., New York, N.Y.  
Jacobs, Elbridge C., Univ. of Vermont, Burlington, Vermont.  
Jenks, William F., Dept. of Geology, Harvard University, Cambridge, Massachusetts.
- Johnson, J. Harlan, Box 343, Golden, Colorado.
- \* Johnston, R. A. A., 112 Old Forest Hill Rd., Toronto 10, Ontario, Canada.  
Jolliffe, Fred T., Graduate College, Princeton, New Jersey.  
Jones, Gardner H., Box 136, West Lebanon, New Hampshire.
- Karlsson, A., 265 E. 201st St., New York, N.Y.  
Karpinsky, R. E., Manawa, Wisconsin.  
Keller, W. D., 201 Swallow Hall, Columbia, Missouri.
- \* Kerr, Paul F., Dept. of Mineralogy, Columbia University, New York, N.Y.

- Kerr-Lawson, Mrs. Ferga C., Box 5, Swastika, Ontario, Canada.  
King, Byron F., 21 Maple St., Uniontown, Pennsylvania.
- \* Klein, A. A., Norton Company, Worcester, Massachusetts.  
Knabe, William C., 3853 N. Gratz St., Philadelphia, Pennsylvania.  
Knopf, Adolph, Dept. of Geology, Yale University, New Haven, Connecticut.
- \* Koschmann, A. H., U. S. Geological Survey, Washington, D.C.
- \* Kôzu, S., Mineralogical and Petrographic Inst., Tohoku Imperial University, Sendai, Japan.
- Krantz, F., Herwarthstrasse 36, Bonn, Germany.
- \* Kraus, Edward H., Mineralogical Lab., University of Michigan, Ann Arbor, Michigan.
- Krause, A. T., Grasselli Chemical Co., Experimental Laboratory, 3092 Broadway, Cleveland, Ohio.
- \* Krieger, Philip, Dept. of Geology, Columbia University, New York, N.Y.
- Krishman, M. S., Geological Survey of India, 27 Chowringhee, Calcutta, India.
- Kupas, Julius (Notar), Baïamare, Rumania.
- Kuzbatov, Koann D., 7133 34th St., Berwyn, Illinois.
- \* Landes, Kenneth K., Geology Dept., University of Kansas, Lawrence, Kansas.
- Landon, Robert E., Room 724, U. S. National Bank Bldg., Denver, Colorado.
- \* Lane, Alfred C., 22 Arlington St., Cambridge, Massachusetts.
- \* Larsen, Esper S., 59 Orchard St., Belmont, Massachusetts.
- Lausen, Carol., P. O. Box 1299, Albuquerque, New Mexico.
- Leach, F. I., Lordsburg, New Mexico.
- Lee, D. R., 2515 Channing Way, Berkeley, California.
- \* Lee, O. Ivan, 2684 Boulevard, Jersey City, New Jersey.
- Lemcke, W. L., 609 14th St., Franklin, Pennsylvania.
- Leonard, R. J., Dept. of Geology, University of Arizona, Tucson, Arizona.
- \* Lewis, J. Volney, 6 Linwood Place, White Plains, New York.
- Lind, J. C., Weber College, Ogden, Utah.
- \* Lonsdale, John T., Dept. of Geology, Agricultural and Mechanical College, College Station, Texas.
- \* Louderback, G. D., Dept. of Geology, University of California, Berkeley, California.
- \* Loughlin, G. F., U. S. Geological Survey, Washington, D.C.
- \* Manchester, James G., 34 Nassau St., New York, N.Y.
- Manley, J. A., 132 Hamilton St., New Brunswick, New Jersey.
- Marble, John P., 37 East Bradley Lane, Chevy Chase, Maryland.
- \* Martens, James H. C., 519 Jefferson St., Morgantown, West Virginia.
- \* Mathews, E. B., Dept. of Geology, Johns Hopkins University, Baltimore, Maryland.
- Mawby, M., 330 Chloride St., Broken Hill, New South Wales, Australia.
- May, Timothy, Dept. of Geology, Catholic University, Washington, D.C.
- Maynard, Ernest A., 161-41 86th Avenue, Jamaica, New York.
- \* Maynard, James E., Dept. of Mineralogy, Syracuse University, Syracuse, New York.
- Mayo, Evans B., McGraw Hall, Cornell University, Ithaca, New York.



- \* McCaughey, William J., Lord Hall, Ohio State University, Columbus, Ohio.
- McConnell, Duncan, 475 Harvard St., Palo Alto, California.
- \* McKinstry, Hugh E., 140 Dean St., West Chester, Pennsylvania.
- McLellan, Roy D., 24 Lillian Terrace, Woodbridge, New Jersey.
- McNairn, W. Harvey, McMaster University, Hamilton, Canada.
- McVay, T. N., Prof. of Ceramics, University of Alabama, University, Alabama.
- Melhase, John, 675 Vincente Ave., Berkeley, California.
- Merritt, C. A., University of Oklahoma, Norman, Oklahoma.
- Mertie, J. B., Jr., U. S. Geological Survey, Washington, D.C.
- \* Merwin, Herbert E., Geophysical Lab., Washington, D.C.
- \* Miller, Benjamin L., Lehigh University, South Bethlehem, Pennsylvania.
- Miller, Clarence E., 1689 Broad St., Providence, Rhode Island.
- Miller, Franklin S., 1029 Bryden Rd., Columbus, Ohio.
- \* Miller, William J., Dept. of Geology, University of California, Los Angeles, California.
- Milton, Charles, U. S. Geological Survey, Washington, D.C.
- Monks, Miss Helen M., 415 Prospect Ave., Hartford, Connecticut.
- Montgomery, Arthur, 277 Park Avenue, New York, N.Y.
- Moore, Bernard N., U. S. Geological Survey, Washington, D.C.
- \* Moore, E. S., Dept of Geology, University of Toronto, Toronto, Canada.
- Morgan, Leonard A., 216 Jones Ave., Burlington, New Jersey.
- Morgan, L. P., U. S. Assay Office, 32 Old Slip, New York, N.Y.
- Morton, James F., Paterson Museum, Paterson, New Jersey.
- Murphy, Richard, Dome Mines Club #1, South Porcupine, Ontario, Canada.
- Murray, Albert N., Dept. of Geology, University of Tulsa, Tulsa, Oklahoma.
- Nemoto, Tadahiro, c/o Rigakubu Chi Skitsugaku Kyoshitsu, Hokkaido Teikoku Daigaku Sapporo, Hokkaido, Japan.
- Newcomb, C. A., Jr., Route 3, Pontiac, Michigan.
- Newcomet, William S., 3501 Baring St., Philadelphia, Pennsylvania.
- \* Newhouse, W. H., Dept. of Geology, Room 4-348, Massachusetts Institute of Technology, Cambridge, Massachusetts.
- \* Niggli, Paul, Eidgenössische Technische Hochschule, Zürich, Switzerland.
- Noble, James A., Homestake Mining Co., Lead, South Dakota.
- \* Nolan, Thomas B., U. S. Geological Survey, Washington, D.C.
- Nutting, P. G., U. S. Geological Survey, Washington, D.C.
- O'Connell, Daniel T., Dept. of Geology, College of the City of New York, 139th St. & Convent Ave., New York, N.Y.
- Odum, W. J., 517 Insular Life Bldg., Manila, Philippine Islands.
- Okada, Ietaka, Chemical Laboratory, The Shanghai Science Institute No. 120, Route Ghizi, Shanghai, China.
- Oldach, Frederick M., 323 Wellesley Road, Philadelphia, Pennsylvania.
- Olmstead, Frank R., 709 Lawrence St., Ann Arbor, Michigan.
- \* Orcel, Jean, Museum d'Histoire Naturelle, 61 Rue de Buffon, Paris, France.
- Otersen, Lillian, 16 Grove Place, Prospect Beach, West Haven, Connecticut.
- Over, Edwin J., Jr., 1316 No. Prospect St., Colorado Springs, Colorado.
- \* Pabst, Adolf, Dept. of Geology, University of California, Berkeley, California

- \* Palache, Charles, 106 Appleton St., Cambridge, Massachussets (Life Fellow).
- Palumbo, Roberto, 2 via Gerolama Fracastoro, Rome, Italy.
- Park, Charles F., Jr., U. S. Geological Survey, Washington, D.C.
- \* Parker, Robert L., Mineralogisches Institut d. eidgen. Techn. Hochschule, Sonneggstr. 5, Zurich 6, Switzerland.
- \* Parsons, A. L., Dept. of Mineralogy, University of Toronto, Toronto, Canada.
- \* Peacock, Martin A., Dept. of Mineralogy, Harvard University, Cambridge, Mass.
- \* Peck, Albert B., Mineralogical Lab., University of Michigan, Ann Arbor, Michigan.
- Peck, Harry S., 10 Lyon Avenue, Albany, New York.
- Pegau, Arthur A., University of Virginia, Charlottesville, Virginia.
- Perkins, Edward H., Colby College, Waterville, Maine.
- Perry, Elwyn L., Dept. of Geology, Williams College, Williamstown, Massachusetts.
- Pfordte, Otto F., Cairo, Greene Co., New York.
- Philbrick, S. S., Dept. of Geology, Johns Hopkins University, Maryland.
- \* Phillips, Alexander H., 54 Hodge Rd., Princeton, New Jersey.
- Pohl, John C., 204 North Tenth St., Easton, Pennsylvania.
- Pohndorf, August, Jr., 758 Monroe St., Denver, Colorado.
- Poindexter, O. Floyd, Michigan Geological Survey, Lansing, Michigan.
- Poor, R. S., Birmingham-Southern College, Birmingham, Alabama.
- Pough, Frederick H., 4 Lenox Place, St. Louis, Missouri.
- Ramdohr, Paul, Emmichstrasse 160, Aachen, Germany.
- \* Ramsdell, Lewis S., Mineralogical Lab., University of Michigan, Ann Arbor, Michigan.
- Reamer, Louis, 482 Lincoln Ave., Orange, New Jersey.
- Reyes, Jorge Munoz, Apartado 267, La Paz, Bolivia, South America.
- \* Richardson, C. H., Syracuse University, Syracuse, New York.
- \* Ries, H., Dept. of Geology, Cornell University, Ithaca, New York.
- \* Rogers, Austin F., Stanford University, California.
- Rosenberg, Sig. Ernesto Romano, Via Mezzocannone 31, Napoli 70, Italy.
- Rosenkrans, R. R., 243 Park Ave., State College, Pennsylvania.
- Rosicky, V., Univ. Masaryk's Brno, Kounicova 59, Republic Czecho-Slovakia.
- \* Ross, Clarence S., U. S. Geological Survey, Washington, D.C.
- Rowley, Elmer, 15 Shippey St., Glens Falls, New York.
- \* Runner, J. J., Old Science Bldg., University of Iowa, Iowa City, Iowa.
- \* Russell, A. E., Swallowfield Park, Reading, Berkshire, England.
- Rutherford, Ralph L., Dept. of Geology, Univ. of Alberta, Edmonton, Alberta, Canada.
- Sahlin, Carl, Djursholm, Sweden.
- \* Sampson, Edward, Dept. of Geology, Princeton, New Jersey.
- Sanborn, Frank, 2031 Los Angeles Ave., Berkeley, California.
- Sandberg, Adolph E., Geology Dept., Univ. of Cincinnati, Cincinnati, Ohio.
- \* Schairer, J. F., Geophysical Lab., 2801 Upton St., Washington, D.C.
- \* Schaller, Waldemar T., U. S. Geological Survey, Washington, D.C.
- \* Schneider, Hyrum, University of Utah, Salt Lake City, Utah.

- \* Schneiderhöhn, Hans, Mineralogisches Institut der Universität Freiburg, Burgerstrasse 30, Freiburg, Germany.
- \* Schoep, Alfred, Dept. of Mineralogy, University of Ghent, Ghent, Belgium.
- \* Schrader, Frank C., 21 Old Chester Road, Bethesda, Maryland.
- Scott, Horace, A., 2208 North Ross St., Santa Ana, California.
- Selfridge, George Jr., American Smelting and Refining Co., Apartado Num. 6, Compostela, Nayarit, Mexico.
- Sensenig, Wayne, 309 Bangor Road, Bala-Cynwyd, Pennsylvania.
- Shaub, Banj. M., 16 Paradise Road, Northampton, Massachusetts.
- Shenon, P. J., U. S. Geological Survey, Washington, D.C.
- Shipton, W. D., Dept. of Geology & Geography, Washington University, St. Louis, Missouri.
- Shone, T. L. H., P. O. Box 20, Postmasburg, Hay, South Africa.
- \* Short, Max N., Dept. of Geology, University of Arizona, Tucson, Arizona.
- Shrader, John J. S., 184 Alvin St., Freeland, Pennsylvania.
- Simondetti, Luigi, via Carlo Alberto 38, Turin, Italy.
- \* Simpson, Edward S., Government Lab., Wellington St., Perth, Western Australia.
- Skea, E. M., P. O. Box 46, Pilgrims Rest, Transvaal, South Africa.
- \* Slawson, Chester B., Mineralogical Lab., University of Michigan, Ann Arbor, Michigan.
- Snelgrove, Alfred K., Dept. of Geology, Princeton University, Princeton, New Jersey.
- Sniffen, E. W., 3111 Boulevard, Hampton, Virginia.
- Sohlberg, Rudolph G., 982 Prospect St., Honolulu, Hawaii.
- Speiss, Moritz P., Marburg-Lahn, Germany.
- \* Spence, Hugh S., Mines Branch, Sussex St., Ottawa, Canada.
- Stadnichenko, Miss T., U. S. Geological Survey, Washington, D.C.
- Stanton, Gilman S., 245 W. 104th St., New York, N.Y.
- Staples, Lloyd W., 223 Cowper St., Palo Alto, California.
- Starbird, Leonard H., 19 Craggmere Ave., South Portland, Maine.
- \* Steiger, George, U. S. Geological Survey, Washington, D.C.
- Stevenson, John S., Longacre Long Lac Gold Mines Ltd., Long Lac P. O., Ontario, Canada.
- Stewart, Duncan, 1070 Parker Ave., Detroit, Michigan.
- Stow, Marcellus H., 202 McDowell St., Lexington, Virginia.
- Strock, Lester W., Mineralogical Institute, Krakow University, Golebia 11, Krakow, Poland.
- Stuckey, J. L., 1911 Sunset Drive, Raleigh, North Carolina.
- Sueno, Teiroku, No. 484, 1 Chome, Tamagawa-Okusawa-Cho, Setagaya-Ku, Tokyo, Japan.
- Suffel, G. G., Noranda, Quebec, Canada.
- Sugi, Ushichi, 415 Shimo-Ochiai, (Near Tokyo), Japan.
- Swartzlow, Carl, 201 Swallow Hall, Columbia, Missouri.
- Sweeney, W. A., 954 So. Ardmore Ave., Los Angeles, California.
- Switzer, George, 827 D St., Petaluma, California.
- \* Taber, Stephen, Dept. of Geology, University of South Carolina, Columbia, South Carolina.



- Taiwan, Shokola, Komuka, Taiwan-Sotokufu-Shokusan-Kyoku, Taihoku, Taiwan, Japan.
- \* Tarr, W. A., 704 Westwood Ave., Columbia, Missouri.
- Terpstra, P., Mineralogisch Kristallographisch Institut des Ryks Universiteit, Groningen, Holland.
- Thompson, M. R., 20 Williams Lane, Chevy Chase, Maryland.
- \* Thomson, J. Ellis, Dept. of Mineralogy, University of Toronto, Toronto, Canada.
- Thowless, Herbert L., 255 Fourth St., Newark, New Jersey.
- \* Tilley, C. E., Dept. of Mineralogy and Petrology, University of Cambridge, Cambridge, England.
- Tolman, Carl, Dept. of Geology, Washington University, St. Louis, Missouri.
- Tracy, John M., 2125 S. E. Orange Ave., Portland, Oregon.
- Trainer, David W., Jr., 48 Payne St., Hamilton, New York.
- Trimble, Clinton E., 2903 Dalton Ave., Los Angeles, California.
- Trudell, Harry W., 2030 E. Madison St., Philadelphia, Pennsylvania.
- \* Tunell, George, Geophysical Lab., 2801 Upton St., Washington. D.C.
- Tuthill, Miss Isabel H., Rocky Point, New York.
- Vance, R. C., 300 Hawley St., Rochester, New York.
- Van de Graaff, A., 925 32nd St., Ogden, Utah.
- Varni, Stephen, 15 Maiden Lane, New York, N.Y.
- Vesignie, Jean P. L., 22 Rue de General Foy, Paris VIII<sup>e</sup>, France.
- Vlismas, John, 235 East 78th St., New York, N.Y.
- \* Von Eckerman, Harry, Sparreholm, Sweden.
- \* Von Schlichten, Otto, University of Cincinnati, Cincinnati, Ohio.
- Vonsen, M., Petaluma, California.
- Wahlstrom, E. E., 2010 Broadway, Boulder, Colorado.
- Waldschmidt, W. A., 1204 Cherokee St., Apt. No. 1, Denver, Colorado.
- \* Walker, T. L., Dept. of Mineralogy, University of Toronto, Toronto, Canada.
- \* Wallace, R. C., University of Alberta, Edmonton, Alberta, Canada.
- Walther, P., 508 Muriel Parkway, Elizabeth, New Jersey.
- \* Wandke, Alfred, The Guanajuato Consolidated Mining and Milling Co., Guanajuato, Mexico.
- Washburn, Carlton F., 338 East Jefferson St., Ann Arbor, Michigan.
- \* Watanabe, Manjiro, Tohoku Imperial University, Sendai, Japan.
- Watson, E. H., Dept. of Geology, Bryn Mawr College, Bryn Mawr, Pennsylvania.
- Wedel, Arthur, Box 595, Holdenville, Oklahoma.
- Weidhass, Ernest, 63 Iden Avenue, Pelham Manor, New York.
- \* Weidman, Samuel, 512 Lahoma St., Norman, Oklahoma.
- Wellnitz, Miss Anna M., Brooklyn College, 66 Court St., Brooklyn, New York, N.Y.
- \* Wells, Roger C., U. S. Geological Survey, Washington, D.C.
- \* Westgate, Lewis G., 124 Oak Hill Ave., Delaware, Ohio.
- \* Wherry, Edgar T., 27 Oberlin Ave., Swarthmore, Pennsylvania.
- Whiting, H. C., 602 South Main St., Fairfield, Iowa.
- \* Whitlock, Herbert P., America Museum of Natural History, New York, N.Y.
- Wieczor, Steven R., 2755 Wilson Ave., Chicago, Illinois.



- \* Wigglesworth, Edward, Boston Society of Natural History, 234 Berkeley St., Boston, Massachusetts. (Life Fellow).
- Wilkinson, W. D., Geology Dept., Oregon State Agricultural College, Corvallis, Oregon.
- Wiley, L. M., Research Lab., General Electric Co., Schenectady, New York.
- Wilson, E. H., 37 Forest Ave., Caldwell, New Jersey.
- \* Winchell, Alexander N., Dept. of Geology, University of Wisconsin, Madison, Wisconsin.
- Wishart, James S., 1186 Lake Ave., Rochester, New York.
- Withrow, James R., 77 16th Ave., Columbus, Ohio.
- \* Wolff, John E., 360 South Grand Ave., Pasadena, California.
- Woodford, A. O., 443 West 10th St., Claremont, California.
- Woods, Arthur E., 208 Centre St., Orange, New Jersey.
- \* Wright, Fred E., Geophysical Laboratory, Washington, D.C.
- Wuestner, Herman, 3335 Cavanaugh Ave., Westwood, Cincinnati, Ohio.

Yatsevitch, Gratian M., 4 Bradford Rd., Watertown, Massachusetts.

Zodac, Peter, 157 Wells St., Peekskill, New York.

## NOTES AND NEWS

### TEACHING FELLOWSHIP IN MINERALOGY

A teaching fellowship in mineralogy has been established at Stanford University. This fellowship is open to graduate students who intend to specialize in mineralogy, and preference will be given to those who have had one or two years of graduate work. The chief duty of the fellow is to assist in laboratory instruction. Not more than eight or nine hours work a week will be required. The amount of the fellowship is \$750.

Application for the year 1935-36, accompanied by testimonial letters, should be made to Professor Austin F. Rogers, Box 87, Stanford University, California.

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### Correction

On page 321 of the July 1933 issue of *The American Mineralogist* the mineral collection of Emory University Academy is listed at Oxford, Georgia. This collection should be listed as Emory University Collection at Atlanta, Georgia.

The collection consists of about one thousand specimens and is housed in the Physics Building. It is open to visitors on week days from 8 A.M. to 5 P.M.